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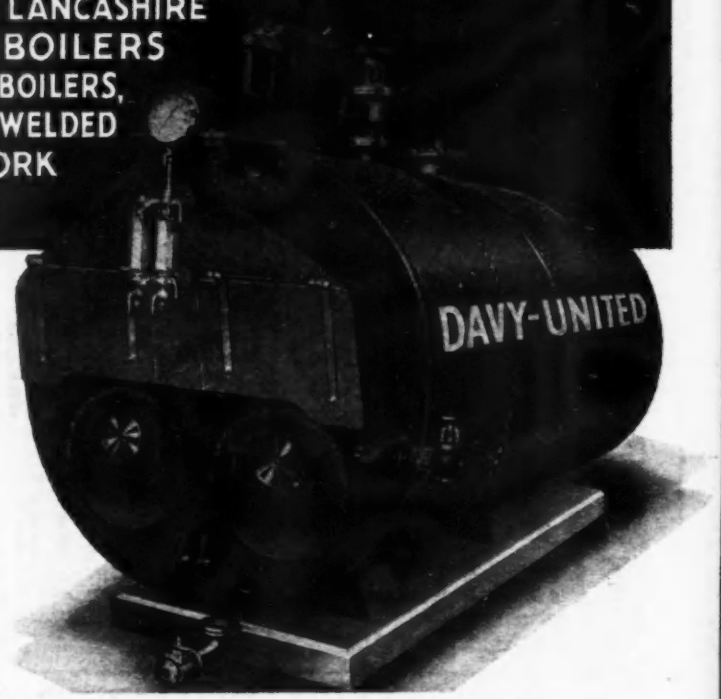

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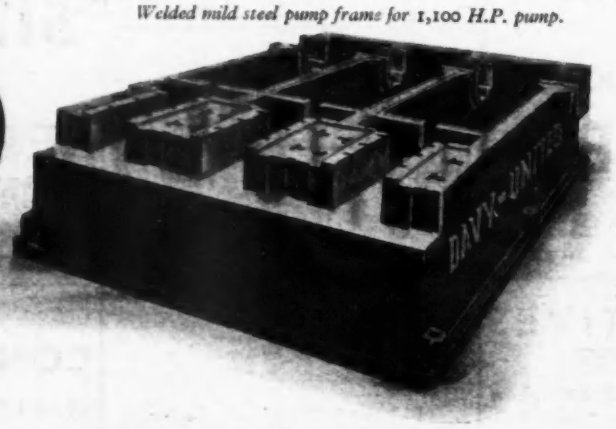

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REPAIR BY WELDING OF A CAST-STEEL HYDRAULIC CYLINDER.

WELDING as a method of repair has become scarcely less important, certainly under present conditions, than as a method of fabrication, a pertinent example being the welding of the cast-steel cylinder of a 2,000-ton cable-sheathing press. Some account of this operation is given below and illustrated by Figs. 1 to 13, on Plate XXV, on this page and on page 476. The press is part of the cable-sheathing equipment of Messrs. Aberdare Cables, Limited, South Wales, and the failure of its cylinder on January 27 of this year naturally put it at once out of action. As the firm was engaged on important work, it was imperative that the press should not remain idle for a day longer than could possibly be avoided. It was found that a replace cylinder could not be obtained from the original makers under eight months, these makers being a firm of French engineers and war conditions accounting for the long delay. In these circumstances it was decided to transport the damaged cylinder, along with its ram, which had seized, to the Derby Works of Messrs. International Combustion, Limited, 19, Woburn-place, London, W.C.1, for the manufacture of a new cylinder. As the combined cylinder and ram weighed 21 tons, its carriage was not a simple matter and the difficulties were increased by the severe weather conditions then prevailing, unusually heavy snowfalls having completely blocked some sections of road and rail. The press was, however, dismantled and the cylinder dispatched from Aberdare on Friday, February 2, reaching Derby on Sunday, February 4, this rapid cross-country transit being effected by the co-operation of the Great Western and London, Midland and Scottish Railways.

FIG. 10. 2,000-TON CABLE-SHEATHING PRESS IN OPERATION.

The condition in which the cylinder arrived at the International Combustion works is shown in Fig. 1, Plate XXV. The crack is clearly visible and extends from top to bottom through the heavy ribs connecting the column bosses. To understand the construction of the cylinder the general view of the press given in Fig. 10, on this page, should be referred to. In this view, the upper part of the ram is just visible above the floor, the cylinder being completely hidden. It will be realised, however, that the four columns carrying the entablature are anchored at the bottom to the top of the cylinder.

The structure attached to the ram moves upwards when the press is working, the lead sheathing being formed on the cable by the resistance of the small ram attached to the entablature. The press is capable of covering cables up to 4 in. in diameter and operates with a hydraulic pressure of 3 tons per square inch, the total load on the main ram being rather more than 2,000 tons. The extent of the crack in the cylinder, seen in Fig. 1, is more clearly shown in Fig. 2, Plate XXV. This shows the major portion of the cylinder, with the seized ram, after the two portions had been separated by means of wedging; they had been held together by the small area of unbroken metal, distinguishable by its lighter colour in Fig. 2, at the top left-hand corner of the cylinder. It may be mentioned here that the cause of the failure has not been definitely established. Slag inclusions and blow-holes were visible, however, in the fractured surfaces while the ram appeared to have scored the walls of the cylinder, probably through mis-alignment, although the surface of the ram itself was in perfect condition. Besides the macroscopic inclusions, microphotographs of polished specimens showed that smaller slag inclusions and cracks also existed throughout the metal. The chemical analysis of several specimens gave, as an average, carbon, 0·54 per cent.; silicon, 0·27 per cent.; manganese, 0·76 per cent.; chromium, 0·12 per cent.; phosphorus, 0·01 per cent. maximum; and sulphur, 0·04 per cent. maximum.

The first problem in the repair was the removal of the seized ram. The seizing was considered to be due to the contraction of the cylinder casting when the internal cooling stresses were relieved by its fracture, these stresses not having been previously relieved either by annealing or by normalising. As will be inferred from the use of the term "major" in referring to the two portions of the cylinder, the crack did not take place across a true diameter but slightly to one side of it, so that the ram was partially embraced. An attempt was made to release the ram by drilling a number of closely-pitched holes in the cylinder along its bearing surface on the ram. This operation is shown in progress in Fig. 3, Plate XXV. It proved, unsuccessful, however, so the cylinder was mounted on a horizontal planing machine and grooves were cut in the bearing area. This released the ram, as is evident from Fig. 4, Plate XXV, in the upper part of which the grooves are plainly visible. It will be noticed also in this view that the appearance of the fracture is quite different from that seen in Fig. 2. The reason for the change is that, at this stage, it was realised that, since a pattern would have to be made and there was foundry congestion, a new casting would take several months to complete. As time was the all-important factor, it was therefore decided to repair the casting by welding and to insert a forged-steel liner. The fractured surface in Fig. 4 has had its edges partially trimmed by oxy-acetylene blowpipe preparatory to this welding; hence the difference in appearance from the view of Fig. 2.

To understand the method of repair outlined above, the sectional drawing, Fig. 13, page 476, should be referred to. After welding, the cylinder casting was bored out with two shoulders, as shown, the body being reduced in thickness from 9 in. to $3\frac{3}{8}$ in. Clearly, such a reduction would weaken the cylinder so that it would not stand the working pressure of 3 tons per square inch. The liner was accordingly designed to take the pressure, this condition being ensured by having a clearance of $\frac{1}{16}$ in. between the outer surface of the liner and the inner surface of the re-bored cylinder. The liner is 5 in. thick in the body. It will be noticed that the liner is closed at the bottom, this taking the place of the bottom of the cylinder, which was removed by a trepanning operation. This construction involves the taking of the working load, approximately 2,000 tons, by the liner and its transference to the cylinder casting by means of the 2-in. shoulder seen at the top of the drawing. The studs, $1\frac{1}{2}$ in. in diameter, above the shoulder do not take any of this load, but merely prevent rotation of the liner in the cylinder. The narrow bottom shoulder on the liner likewise does not bear any load, as it is clear of the corresponding shoulder of the casting in order to allow for expansion of the liner.

The load is transmitted from the cylinder to the columns, which are in tension between the cylinder and the entablature when the press is at work. This causes a certain amount of bending stress in the cylinder, this stress being at a maximum at the base. In order to avoid any possibility of overstressing the weld metal in the cylinder, therefore, a ring of carbon-chromium steel, $3\frac{5}{16}$ in. thick by $6\frac{1}{4}$ in. deep, was shrunk on to the cylinder at the base, as shown, a thinner mild-steel ring being welded on the cylinder body roughly half-way between the base ring and the column lugs. The bottom of the liner was made a sliding fit at the bottom of the cylinder, the rest of the liner being clear of the cylinder, as already stated. The gap

REPAIR BY WELDING OF FRACTURED CAST-STEEL HYDRAULIC CYLINDER.

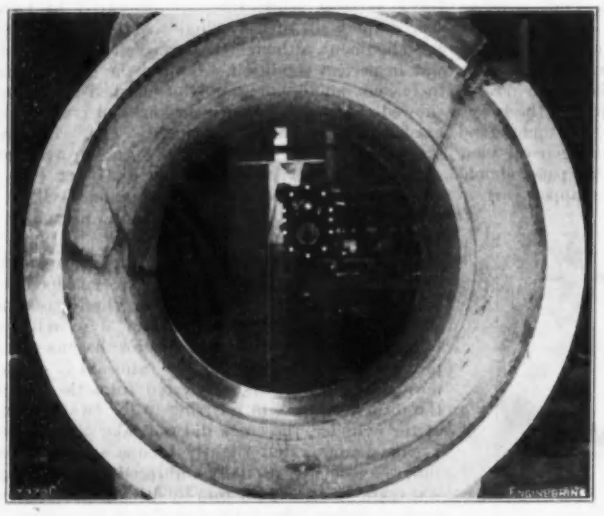


FIG. 11. INTERIOR OF RE-BORED CYLINDER.

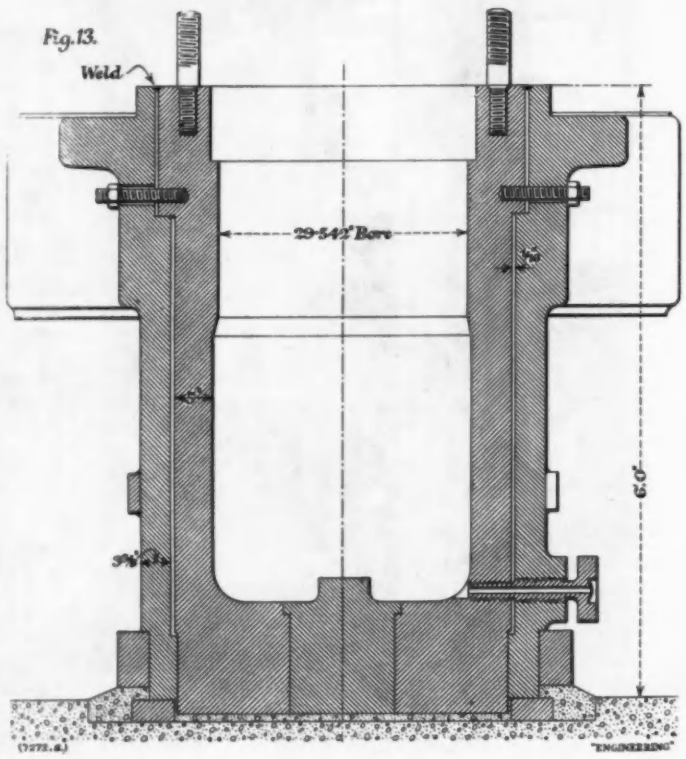
FIG. 12. COMPLETED CYLINDER IN PLACE.

caused by this clearance at the top of the liner was sealed by welding. The ram is not in contact with the full length of the liner, but only for some 18 in. at the top below the gland recess. The flanged hydraulic connection at the base is screwed into the liner, and has also a welded seal, but passes through a clearance hole in the cylinder to allow for relative movement due to expansion. The cylinder rests on cast-iron seating blocks. The central plug seen in the bottom of the liner was inserted as, during machining, segregations were discovered at this point, and it was considered advisable to cut out the affected area to a diameter of 12½ in. and then to shrink in the spigoted steel plug. The projecting centre portion of the plug forms an end stop for the ram, and the shoulder on it takes up any shock.

The repair of the cylinder by welding having been tentatively decided upon, it was necessary, before proceeding with the work, to find out what materials were available for the liner, etc., since it was on the existence of these materials that the possibility of completing the repair in considerably less time than that required for the production of a complete new casting depended. Inquiries made in Sheffield resulted in the finding, in the works of Messrs. English Steel Corporation, Limited, Vickers Works, Brightside, of a stock rotor ingot, of a suitable size for the liner, of 3 per cent. nickel steel. For the base ring, a suitable forged carbon-chromium ring was selected from the parts normally used in the coal-pulverising mills manufactured by Messrs. International Combustion, Limited, this ring being the unit of the mill known as the "bull" ring. The way was then clear for the welding of the cylinder, which operation may now be described. The first stage is seen in Fig. 5, Plate XXV. Here the two portions of the cylinder are shown assembled ready for welding, all doubtful material and obvious slag inclusions having been removed from the fractured surfaces by oxy-acetylene blowpipe and the crack being cut back from the outer surface of the cylinder in a Vee measuring about 3½ in. deep by about 5 in. wide at the surface.

The actual welding operation is shown in progress in Fig. 6, Plate XXV. It occupied a whole week, both day and night shifts being worked, and during this time over 3,000 electrodes were used, this consumption representing the deposition of over 5 cwt. of metal. The electrodes were the "Fastex" type 5 A, made by Messrs. Murex Welding Processes, Limited, Thames House, Millbank, London, S.W.1. During welding a coke fire was kept burning in a brazier inside the cylinder in order to preheat the metal to some extent and so prevent contraction cracks. The nature of the welding is clearly seen in Fig. 7, Plate XXV. Different sizes of electrodes were used at different stages, viz., No. 8 at the bottom of the Vee, followed by No. 6, and finally by No. 4. After the joint had been filled, straps were welded across it in order to ensure rigidity during the subsequent machining operations. On completion of the welding, the bottom of the cylinder, which was 11½ in. thick, was trepanned by means of an oxy-acetylene blowpipe. It may be noted that the first attempts were unsuccessful as the burner available did not produce a sufficiently penetrating flame. A satisfactory burner was eventually obtained from Messrs. The British Oxygen Company, Limited, Thames House, Millbank, London, S.W.1.

The welded cylinder was then bored out to accommodate the liner. This operation was done on a vertical boring machine, as shown in Fig. 8, Plate XXV. The work occupied ten days of continuous operation, this time including setting up first one end and then the other and repeating for the finishing cut. The amount by which the cylinder thickness was reduced has already been stated, the actual cutting involving the removal of more than 6½ tons of metal. Here, again, difficulties attended the first stages of the work, since the occurrence of extremely hard patches of metal and slag inclusions was very severe on the tools first used. Eventually, however, by the employment of a tool steel known as "Superweld Stag Major," made by Messrs. Edgar Allen and Company, Limited, Eyam, Sheffield, the machining was satisfactorily finished. A view of the interior of the finished bored cylinder, showing the position of the original cracks, is given in Fig. 11, on this page.



While the cylinder was being welded and machined at Derby, Messrs. English Steel Corporation had finish-bored the solid ingot for the liner and rough-turned it outside. Unfortunately, during these machining operations it was found that the ingot contained segregations at the centre and these had to be cut out and the hole filled in by a plug as already described. The bottom of the liner was left slightly thicker than it would otherwise have been in order to compensate for the fitting of the plug. Of course, had the ingot been used for its original purpose as a rotor the segregations would have been automatically cut out when the hole for the shaft was bored. As it was, the difficulty was not insurmountable though it meant spending three or four more days on the work, the liner arriving at Derby on February 28. Thereafter the top face was fitted with the gland studs and on the morning of March 1 the liner and cylinder were assembled, and, after adjustment for the side clearance, were seal-welded at the top. Finally, the forged carbon-chromium ring was shrunk on, the hydraulic connection fitted and seal-welded, and the complete assembly dispatched to Aberdare. It reached its destination on March 2 in the condition shown in Fig. 9, Plate XXV. In this view the base ring, the intermediate ring and the weld seam straps are all clearly visible. The holes seen in two of the column lugs were tapped for set screws required to facilitate adjustment of the two columns concerned, the lug holes being found slightly out of centre

with the corresponding ones in the entablature. A view of the top of the completed cylinder, in position in its foundation, is given in Fig. 12, on the opposite page. In this, the seal-weld and the tops of the crack weld are visible.

The press was put into operation on March 6 and has since, we understand, been working quite satisfactorily. The total delay from the breakdown to re-starting was thus under six weeks, of which four weeks were occupied on the repair at Derby, this time representing a very considerable saving on the period of eight months stated to be required to obtain a replace cylinder from the original makers of the press.

LITERATURE.

The Design of Propeller Pumps and Fans. By M. P. O'BRIEN and R. G. FOLSOM. California University Publications in Engineering, Vol. 4, No. 1, 1939. Berkeley: The University Press. [Price 50 cents.]

THE study of aerodynamics and the application of organised research to the problems of flight are not only successfully meeting the needs of aeroplane design but they are giving a stimulus to other branches of engineering. A fruitful field of research has arisen in an attempt to connect up theoretical work with the actual design of propeller pumps and fans. Although this publication is not the first on this subject by the same authors, it presents the results of their recent experiments in a convenient form, and in a manner which will be appreciated by those concerned with the design of axial-flow pumps. Unfortunately, progress in this direction depends in no small measure on the results of wind-tunnel tests and other researches in air flow. Much more information is still needed, such as the pressure distribution over blade sections and the question of the direction and magnitude of the fluid velocity for aerofoils in cascade when computing the lift and drag, using data obtained from wind-tunnel tests with single aerofoils.

A little more than half the publication is devoted to aerodynamic theory relating to the basic principles concerned in pump design, and includes sections on separation, cross-flow, cavitation and cascade effect. Finally, there are sections dealing with the analysis of existing units and the verification of theory. In the part containing an example in design, the aerofoils chosen for the sections of the impeller blades and guide vanes have been selected from the N.A.C.A. series, and the curves of lift and drag coefficients, which are from wind-tunnel tests, have been redrawn for infinite aspect ratio. The application of the developed equations assumes that the presence of the hub and casing results in flow conditions around the blades similar to those around an aerofoil of infinite aspect ratio, but no reference is made to the radial gap between the tip of the impeller blades and the casing. The accuracy of the application of the theory depends greatly upon the use of small gaps. The equations are sufficient to determine the characteristics of a propeller, and in the design example certain simplifications are pointed out.

In the design of axial-flow pumps, unlike that of fans, the problem of cavitation is one of the controlling factors, but present-day knowledge of the subject is still in an unsatisfactory state. Because of the higher relative velocity in this region, cavitation first appears near the blade tips as the discharge is increased, and the authors recommend that the blade section and angle of attack at the tip should be chosen so as to permit operation without cavitation at 125 per cent. of the rated capacity. Computation of the pressure reduction at the tips of some propeller-pump blades, during what appeared to be satisfactory operation, gave pressures below absolute zero, leading to the conclusion that, either the coefficients for aerofoils are larger than are applicable to pumps, or the period required for the flow to traverse the low-pressure area is too short for cavities to develop. Curves of pressure-reduction coefficients as a function of lift coefficients are presented. These are based on aerofoil data, described in the paper and modified in the light of the observed cavitation limits of satisfactory pumps.

The authors have shown by test results that the measurements of the head-capacity characteristics of a pump, designed with certain conditions of chord length/blade separation, are sufficiently closely in agreement with the predicted values for the mutual interference of blades not to be of major importance; but in this design the operating point on the lift curve of the blade sections is at 60 per cent. of the maximum, and the above may not be true should it be necessary to design at a higher point on the lift curve. True, the theoretical investigations of Numachi and others on this effect do not agree wholly with the experimental results of Keller and Ober, and it appears that this is a field for further useful research.

The predicted characteristics for the experimental pump are shown in a series of curves and are compared with observed characteristics from an actual test. The agreement is remarkably close and substantiates the principal features of the theory as outlined by the authors, appearing to demonstrate that it is possible to design a pump or fan for a specified condition within reasonable limits by the theoretical design equations. To enable the designer to solve the equations readily for a complete design, a useful graphical solution chart is embodied in the publication. The data are based upon the same series of aerofoils as selected for the experimental pump. The diagrams are very good and there is a bibliography which does justice to American and German contributions on the subject. The authors have made a good contribution to the literature on pumps and fan design, in a domain which had not received much attention.

A Text-Book of Heat. In two parts. By PROFESSOR H. S. ALLEN and R. S. MAXWELL. London: Macmillan and Company, Limited. [Prices: Part I, 10*s.*; Part II, 10*s.* 6*d.*]

THIS work has been designed to bridge the gap between the elementary text-book and the comprehensive treatise. Part I is mainly descriptive and experimental. It opens with a historical introduction which briefly surveys the development of the subject from the speculations of the early philosophers to the modern conception of the kinetic theory of heat. The value of this section is enhanced by an instructive series of biographical notes at the ends of the chapters. The authors have shown wisdom in developing their subject on a combination of the experimental and the theoretical, for it is chiefly through the interaction of experiments, speculations and theories that progress in science has been achieved. For this reason, the inclusion of modern researches on calorimetry, conductivity, specific heat, etc., is a feature to be commended. The subject matter is comprehensive and well presented, and includes references to meteorology, which has now assumed such importance. The fundamental laws of heat connected with this branch of science are dealt with in two chapters, which also describe some modern developments.

Under the heading of Heat Engines, an attempt has been made to show the practical application of the work done by a gas in steam and internal-combustion engines, and in steam turbines; but to pass from a ten-line account of Watt's patent to a six-line description of the compound engine, locomotive, turbine, etc., is hardly consistent with the rest of the work. This part should either have been treated more adequately or omitted entirely. A statement that "turbines are used as prime movers in large land power stations for the generation of electricity, and units may be of 30,000 h.p. to 40,000 h.p." presents a very incomplete picture, because it ignores the considerable manufacture of smaller units and implies that they are of no consequence.

Part II is largely of a theoretical and advanced character. It opens with the laws of thermodynamics and deals adequately with conduction, convection, radiation and the quantum theory. Einstein's and Debye's theories of specific heat are also included, while statistical method and probability receive special consideration. The surveys of the mathematical theory of conduction, the treatment of heat transmission by radiation, natural and forced convections, are likely to prove useful, but it is to be regretted that the variation of specific heat of gases with temperature, and the supersaturated expansion of vapours, have received no attention.

This work possesses many features which distinguish it from a mere class book. Although specially intended for students reading for pass and honours degrees in physics, it contains frequent references to the application of the laws of heat and thermodynamics to engineering science, which should recommend it to the attention of practising engineers.

The Road and Rail Transport Problem. By BRIGADIER-GENERAL SIR H. OSBORNE MANCE. London: Sir Isaac Pitman and Sons, Limited. [Price 7*s.* 6*d.* net.]

To assume from the title of this book that current events have rendered it out of date would be erroneous. Certainly, national unity and the emergency measures taken to control transport have temporarily shelved the road-rail dispute, and the "Square Deal" poster has been replaced by a very different style of advertisement; but the problem has not been solved, and will surely re-emerge as one of the more pressing of post-war reconstruction problems. Sir Osborne Mance writes with authority and with admirable impartiality as well as literary ability. He brings to this intricate, vexed and ubiquitously far-reaching question a capacity for clarifying the issues and reducing them to manageable components which earlier treatments too often have lacked. Dismissing proposals for unrestricted competition as being incapable of producing a balanced settlement, even if they did not prove to be positively destructive, he postulates the problem as a need so to co-ordinate the different forms of transport as to ensure that every passenger and every ounce of goods shall travel by the most economical route and the most suitable vehicle. He makes it abundantly clear that four railway systems and sixty thousand road undertakings cannot be compared, but can, and must, be co-ordinated; and stresses the impracticability of effecting co-ordination until such time as the vast number of road-transport units can be associated into a few large and disciplined groups, able and willing to make terms and to keep them. The significance of the fact that about three-quarters of the road transport in the country consists in private haulage power, some 80 per cent. of which is constituted by local-delivery services which do not immediately affect the problem, has not been missed; but the lack of ample road-transport statistics is regretted. Above all, the author, while free from concern about votes, is fully alive to the interests of the individual transport user and the taxpayer, as well as to the many responsibilities of the Government.

The first part of the book sketches recent transport history in this country and briefly outlines the attempts made, with more or less success, to co-ordinate transport systems in several other countries. The economic nature of the problem is analysed and alternative possible solutions are offered with objective detachment. A good deal of space is necessarily devoted to condensations of the reports produced by advisory bodies which have considered the problem. In Part II, the material features of several authoritatively proposed remedies are subjected to a critical examination by the author, who then advances his own proposal of a composite, long-term scheme, together with suggestions as to immediate steps which might be taken to implement it. The book is well indexed, and deserves the careful attention of all students of transport problems.

THE INSTITUTE OF WELDING.—The address of the offices of the Institute of Welding is now 2, Buckingham Palace-gardens, Buckingham Palace-road, London, S.W.1.

CEMENT MANUFACTURE IN SOUTH AMERICA.—The combined population of Mexico, South and Central America, and the West Indies, is almost identical with that of the United States, yet, according to figures compiled by the Bureau of Mines at Washington, these countries possess only a total of 35 active cement-making plants, as compared with 151 plants in the United States in 1938. There are seven plants in Mexico, nine in Argentina and six in Brazil. The Bureau concludes that there is a large potential market for cement in South and Central America, but that its development may be slow.

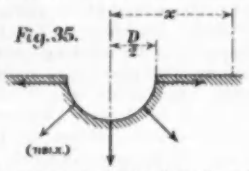
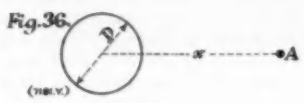
SOME EFFECTS OF SHORT-CIRCUITS ON THREE-PHASE TRANSMISSION LINES.

By T. F. WALL, D.Sc.

(*Continued from page* 406.)

9. *Calculation of the Effective Resistance of the Earth-Current Path.*—When earth currents develop due to short-circuits or due to dissymmetry of the voltages of a three-phase transmission system, it is of great importance to be able to calculate the potential gradient at the earth's surface in the neighbourhood at which the current enters the earth and the practical significance of this potential gradient will be considered in Part II of this article.

TABLE I.—COMPARISON OF EARTH-CURRENT FLOW WITH ELECTRIC FIELD.

Hemispherical Earth Electrode of Diameter D.	Corresponding Quantities.	Charged Sphere of Diameter D in Open Space.
		
(i) Earth current through the surface of the hemisphere is I_e amperes.	$I_e = Q$	(i) Total charge on sphere is 2Q electrostatic units.
(ii) Current density at surface of the hemisphere is $i_0 = \frac{I_e}{2\pi\left(\frac{D}{2}\right)^2} = \frac{2I_e}{\pi D^2}$ amps. per sq. cm. and at distance x cm. from the centre of the electrode is $i_x = \frac{I_e}{2\pi x^2}$ amps. per sq. cm.	$i = \sigma$	(ii) Density of charge on surface of the sphere is $\sigma_0 = \frac{2Q}{\pi D^2}$ electrostatic units per sq. cm.
(iii) Specific resistance of material of earth (assumed to be homogeneous) is ρ ohm per cm. cube.	$\rho = \frac{4\pi}{\epsilon}$	(iii) Electric strain of the dielectric for unit intensity of electric force is $\frac{4\pi}{\epsilon}$.
(iv) Specific fall of potential along the current path is $v_x = i_x \rho$ volt per cm.	$v_x = v_x$	(iv) Intensity of electric force at surface of sphere is $f_0 = \frac{2Q}{\epsilon\left(\frac{D}{2}\right)^2} = \frac{4\pi\sigma_0}{\epsilon}$ dynes, and at any distance x cm. from the centre of the sphere $f_x = \frac{4\pi\sigma_x}{\epsilon}$ dynes. Potential fall along the lines of force is $v_x = \frac{4\pi\sigma_x}{\epsilon}$ ergs. per cm.
(v) Total potential rise at electrode surface due to the earth current is $V = \int_{x=\infty}^{x=\frac{D}{2}} v_x\,dx = I_e\frac{\rho}{\pi D}$ volts.	$V = V$	(v) Potential of surface of the sphere is $V = \int_{\infty}^{\frac{D}{2}} v_x\,dx = \frac{4Q}{\epsilon D}$ ergs.
(vi) "Diffusion resistance" of the earth is $R_e = \frac{V}{I_e} = \frac{\rho}{\pi D}$ ohms.	$R_e = \frac{1}{\text{Capacitance of field due to charge of one hemisphere}}$	(vi) Reciprocal of capacitance for the electrostatic field due to the charged sphere is $\frac{1}{C} = \frac{V}{2Q} = \frac{2}{\epsilon D}$. Reciprocal of capacitance of the field due to the charge on one hemisphere is $\frac{1}{2C} = \frac{4}{\epsilon D}$.

The treatment of such problems relating to earth currents can be greatly facilitated by considering the analogy of the electrostatic field due to charged conductors in an insulating medium. This method of treatment can be well illustrated by a simple example. Suppose, in Fig. 36, a sphere of diameter D is charged with a quantity 2Q units and isolated in space. Then it is a well-known result that the lines of force will be equi-spaced radial lines. At any point A which is distant x cm. from the centre of the sphere the force will be $f_x = \frac{2Q}{\epsilon x^2}$ and the potential at A will be $p_A = \frac{2Q}{\epsilon x}$.

Now consider the hemisphere of diameter D shown in Fig. 35, as embedded in the earth and suppose a current of I_e amperes enters the earth through the surface of this hemisphere. If the material of the earth is homogeneous, the current will flow uniformly in all directions, so that the current density at all points of the surface of any concentric hemisphere of radius x cm. will be uniform and given by the expression

$$i_x = \frac{I_e}{2\pi x^2} \text{ amperes.}$$

In Table I, on this page, are shown in parallel columns the quantities which are characteristic of the electric field and the corresponding quantities which characterise the region through which the flow of the earth current exists. From Table I it will be seen that the total resistance of the earth to the current flow corresponds to the reciprocal of the capacitance of the electrostatic field due to one-half of the charged sphere. Hence, by making use of this correspondence of these characteristic quantities, it is easy to calculate the potential at any point of the earth's surface due to the earth current, when the magnitude of the current which enters the earth is known.

Example.—As an example of a practical case, which will be examined in detail in Part II of this article, may be taken two hemispherical electrodes, each of diameter D and embedded in the earth, as shown in Fig. 37. A current of I_e amperes is assumed to enter the earth through the surface of one hemisphere and to leave the earth through the surface of the other, the distance between the centres of these two electrodes being a cm., where a is taken to be very large as compared with D.

The corresponding electrostatic case is that in which two spheres, each of diameter D and charged respectively with $+2Q$ and $-2Q$ units, are separated in space, the distance between the centres being a cm., as shown in Fig. 38. The lines of force and the equipotential surfaces are shown for the charged spheres in Fig. 1, page 353, *ante*, the methods for drawing these lines of force and equipotential surfaces having been explained elsewhere.* The total capacitance of the electric field due to the two spheres is $\frac{\epsilon D}{4}$. The capacitance of the field up to the median plane M M is $\frac{\epsilon D}{2}$, and the capacitance of the lower half of the field up to this median plane is

$$\frac{\epsilon D}{4}$$

For the corresponding case of the two earth electrodes shown in Fig. 37 the resistance for the earth current flow for each electrode is

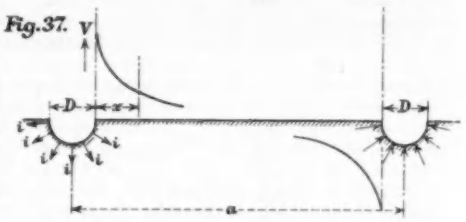
$$R_e = \frac{\rho}{\pi D}$$

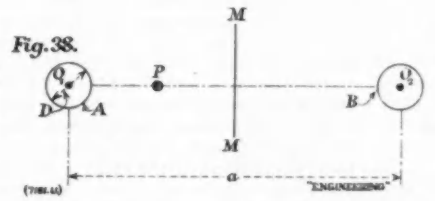
so that the potential at the surface of the electrode at which the current enters the earth is

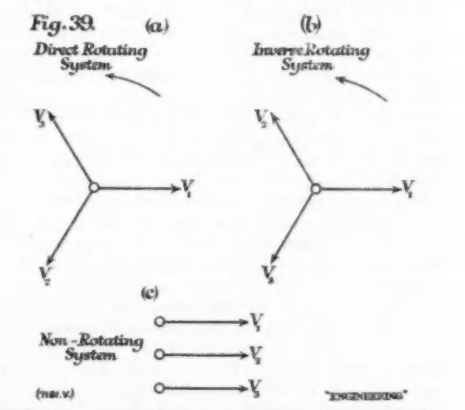
$$V = +I_e\frac{\rho}{\pi D},$$

and the potential at the surface of the electrode at which the current leaves is

$$V = -I_e\frac{\rho}{\pi D}.$$







If the current which passes between each hemispherical electrode and earth is $I_e = 400$ amperes, and if the diameter of each electrode is D = 4 m. = 400 cm., then the resistance to the earth current flow for each electrode is

$$R_e = \frac{10^5}{\pi \times 400} = 80 \text{ ohms},$$

the value of the specific resistance of the earth being taken as $\rho = 10^5$ ohms per centimetre cube.

The potential at the surface of the electrode through which the current enters the earth will be

$$+V = I_e R_e = 8{,}000 \text{ volts},$$

and for the surface of the electrode through which the current leaves the earth will be

$$-V = 8{,}000 \text{ volts}.$$

At any distance x cm. from the centre of the electrode the potential will be

$$V_x = \pm 8{,}000\,\frac{D}{2x}.$$

An important special case is that in which the

* T. F. Wall, *Electrical Engineering*, Section I (Methuen).

earth electrodes are of different diameters, viz., D and d_1. In this case, it is easily seen that the value of the resistance for the electrodes is

$$\frac{\rho}{\pi D} \text{ and } \frac{\rho}{\pi d}, \text{ respectively.}$$

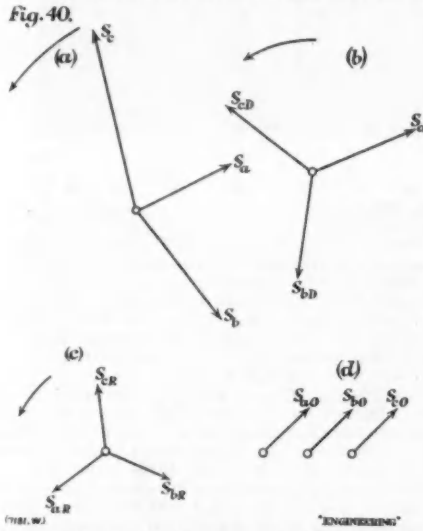
Hence, for a given value of the earth current the potentials of the respective electrodes are given by

$$\frac{V_D}{V_d} = \frac{d}{D},$$

that is to say, the potentials at the surfaces of the electrodes are inversely proportional to the diameters of the respective hemispheres.

10. *Analysis of an Unsymmetrical Three-Phase System into Two Symmetrical and Oppositely-Rotating Three-Phase Systems and a Symmetrical Non-Rotating System.*—This important theorem has many practical applications and is a powerful aid in solving in a relatively simple manner problems which would otherwise be involved and difficult. First consider a symmetrical three-phase system rotating in the standard counter-clockwise direction, as shown in Fig. 39 (*a*). For the moment shown in this diagram, the vector $\mathbf{V}_1$* is directed along

Fig. 40.



the positive real axis, the vector $\mathbf{V}_2$ is obtained by turning $\mathbf{V}_1$ through 240 deg. $\left(\frac{4\pi}{3} \text{ radians}\right)$ in the counter-clockwise direction, and the vector $\mathbf{V}_3$ is obtained by turning $\mathbf{V}_1$ through 120 deg. $\left(\frac{2\pi}{3} \text{ radians}\right)$ in the counter-clockwise direction; that is to say,

$$\mathbf{V}_2 = \mathbf{V}_1 e^{j\frac{4\pi}{3}} : \mathbf{V}_3 = \mathbf{V}_1 e^{j\frac{2\pi}{3}}$$

Calling, for convenience, $e^{j\frac{2\pi}{3}} \equiv \eta$, then

$$\eta \equiv e^{j\frac{2\pi}{3}} \equiv -\tfrac{1}{2} + j\frac{\sqrt{3}}{2}$$

$$\eta^2 \equiv e^{j\frac{4\pi}{3}} \equiv -\tfrac{1}{2} - j\frac{\sqrt{3}}{2}$$

$$\eta^3 \equiv e^{j\frac{6\pi}{3}} \equiv 1$$

$$\eta^4 \equiv e^{j\frac{8\pi}{3}} \equiv \eta.$$

Hence,

$$1 + \eta + \eta^2 \equiv 0 \quad . \quad . \quad (29)$$

A symmetrical three-phase system rotating in the clockwise direction, that is, an inversely rotating system, will be as shown in Fig. 39 (*b*). A symmetrical non-rotating system will be as shown in Fig. 39 (*c*).

Now consider any unsymmetrical three-phase system $\mathbf{S}_a$, $\mathbf{S}_b$, $\mathbf{S}_c$, as shown in Fig. 40 (*a*). It is required to find the equivalent direct and inverse rotating three-phase systems, respectively, and the symmetrical non-rotating system (see Fig. 40 (*b*), 40 (*c*), and 40 (*d*)). If this group of three systems is identical with the original three-phase unsymmetrical system, then:

$$\mathbf{S}_a \equiv \mathbf{S}_{aD} + \mathbf{S}_{aR} + \mathbf{S}_{ao} \quad . \quad . \quad (30)$$

$$\mathbf{S}_b \equiv \mathbf{S}_{bD} + \mathbf{S}_{bR} + \mathbf{S}_{bo} \quad . \quad . \quad (31)$$

$$\mathbf{S}_c \equiv \mathbf{S}_{cD} + \mathbf{S}_{cR} + \mathbf{S}_{co} \quad . \quad . \quad (32)$$

that is,

$$\mathbf{S}_a \equiv \mathbf{S}_{aD} + \mathbf{S}_{aR} + \mathbf{S}_{ao} \quad . \quad . \quad (33)$$

$$\mathbf{S}_b \equiv \eta^2 \mathbf{S}_{aD} + \eta \mathbf{S}_{aR} + \mathbf{S}_{ao} \quad . \quad . \quad (34)$$

$$\mathbf{S}_c \equiv \eta \mathbf{S}_{aD} + \eta^2 \mathbf{S}_{aR} + \mathbf{S}_{ao} \quad . \quad . \quad (35)$$

By adding these three identities, the magnitude of the non-rotating system of vectors is obtained, viz.,

$$\mathbf{S}_{ao} \equiv \tfrac{1}{3}(\mathbf{S}_a + \mathbf{S}_b + \mathbf{S}_c). \quad . \quad . \quad (36)$$

If the expression (34) is multiplied by η, and (35) by η^2, then

$$\mathbf{S}_a \equiv \mathbf{S}_{aD} + \mathbf{S}_{aR} + \mathbf{S}_{ao}$$
$$\eta\, \mathbf{S}_b \equiv \eta^3 \mathbf{S}_{aD} + \eta^2 \mathbf{S}_{aR} + \eta\, \mathbf{S}_{ao}$$
$$\eta^2 \mathbf{S}_c \equiv \eta^3 \mathbf{S}_{aD} + \eta^4 \mathbf{S}_{aR} + \eta^2 \mathbf{S}_{ao}.$$

By adding these three identities, the magnitude of the direct three-phase rotating system of vectors is obtained, viz.,

$$\mathbf{S}_{aD} \equiv \tfrac{1}{3}(\mathbf{S}_a + \eta \mathbf{S}_b + \eta^2 \mathbf{S}_c) \quad . \quad . \quad (37)$$

If the expression (34) is multiplied by η^2 and (35) by η then

$$\mathbf{S}_a \equiv \mathbf{S}_{aD} + \mathbf{S}_{aR} + \mathbf{S}_{ao}$$
$$\eta^2 \mathbf{S}_b \equiv \eta^4 \mathbf{S}_{aD} + \eta^3 \mathbf{S}_{aR} + \eta^2 \mathbf{S}_{ao}$$
$$\eta\, \mathbf{S}_c \equiv \eta^2 \mathbf{S}_{aD} + \eta^3 \mathbf{S}_{aR} + \eta\, \mathbf{S}_{ao}$$

If these three identities are added, the inverse three-phase rotating system of vectors is obtained, viz.,

$$\mathbf{S}_{aR} \equiv \tfrac{1}{3}(\mathbf{S}_a + \eta^2 \mathbf{S}_b + \eta \mathbf{S}_c) \quad . \quad . \quad (38)$$

Example.—Let the three-phase unsymmetrical system be defined by

$$\mathbf{S}_a \equiv 2 + j : \mathbf{S}_b \equiv 2 - 2j : \mathbf{S}_c \equiv -1 + 4j$$

as shown in Fig. 40 (*a*).

The non-rotating system is then given by

$$\mathbf{S}_{ao} \equiv 1 + j$$

The three-phase symmetrical direct rotating system is given by

$$\mathbf{S}_{aD} \equiv 2{\cdot}23 + 0{\cdot}87\, j$$

The three-phase symmetrical inverse rotating system is given by

$$\mathbf{S}_{aR} \equiv -1{\cdot}23 - 0{\cdot}865\, j$$

These three systems are shown in Figs. 40 (*b*), 40 (*c*), and 40 (*d*), respectively, and it is easily shown that they are, taken together, equivalent to the original unsymmetrical three-phase system, Fig. 40 (*a*).

(To be continued.)

* Vector quantities are printed in heavy type.

THE ESTIMATION OF HYDROGEN IN STEEL AND OTHER METALS.*

By W. C. NEWELL, Ph.D.

SINCE about the beginning of the present century, the ever-growing and more exacting requirements of the engineer have caused the metallurgist to devote more and more of his energy to improving the quality of his product. An enormous amount of fundamental research has been conducted into the correlation of the physical properties of metals (especially steel) with their precise mode of production, their chemical composition and their constitution. The discovery that very small additions of other elements can radically affect the properties of metals has added impetus to the development of micro-chemistry, but there are certain non-metallic elements which, while influencing the properties of metals, even when present in minute amounts, call for a specialised technique, more physical than chemical, since they enter or leave the metal in the form of gas. Foremost among the gases which influence the properties of metals is hydrogen, and the object of this paper is to describe an apparatus which has been developed at the Brown-Firth Research Laboratories, Sheffield, for the accurate estimation of hydrogen in metals. The author is indebted to the director of these Laboratories, Dr. W. H. Hatfield, F.R.S., as well as to the other directors of the associated companies, for permission to publish the information herein given.

Recent work which has been carried out upon the hydrogen content of metals has, for the most part, utilised modern high-vacuum technique in the light of the theoretical advances which have been made. The consequence is that, as usual, our knowledge is both more complete and more complex. The mechanism whereby hydrogen is taken up by, or liberated from, a metal involves the processes of adsorption, solution and diffusion. It is to Langmuir that we owe the concept of a mono-molecular layer of physically adsorbed gas. More recently, the results of Roberts, published in 1935, on the hydrogen-tungsten system and the work of Mann and the present author, published in 1937, on the hydrogen-platinum and deuterium-platinum systems indicate that where some chemical affinity exists between the gas and the metal, then at normal temperatures a layer of gas is "chemisorbed" even at very low gas pressures. Since an adsorbed layer of gas can be quite stable upon a metal surface even in quite low gas pressures, it seems likely that in much of the work which has been done upon the removal of gas from metal, the long period of time found necessary for complete removal is due to the fact that the extraction pressure has not been low enough, so that the diffusion process has been hindered by the adsorbed layer. In the apparatus to be described, a high vacuum is maintained by a mercury-vapour pump in continuous operation, and it is suggested that this may account for the relatively short period of time found necessary for complete extraction of the hydrogen.

As regards the effect of temperature upon the rate of diffusion of hydrogen through metals, both experiment and theory give an exponential relationship, so that for the elimination of the gas from the metal it should only be necessary to exceed a certain temperature, and then the rate of elimination should increase rapidly with rise in temperature. This was found to be so for steel, as will be seen from the family of graphs given in Fig. 2, on page 480, showing the relationship between the hydrogen evolved from steel and the time, at various temperatures. The present-day method of estimating the hydrogen content of metals is by melting *in vacuo*, and the author has already described* the apparatus in use in these laboratories for this purpose. The work of the Oxygen Sub-Committee of the Iron and Steel Institute having shown decisively that the effect of hot-working upon steel was to reduce the hydrogen content, Sloman* determined the gas given off from several steel samples when heated *in vacuo* to a temperature of 650 deg. to 700 deg. C. His results show that, after a period of heating of up to 2 hours, gas ceased to be evolved, and that the gas was hydrogen corresponding in amount to that obtained by vacuum fusion. These conclusions have been substantially confirmed and amplified by the present author, and the apparatus described has been designed and constructed to determine the hydrogen content of a dozen or more metal samples consecutively with a minimum of elaborate apparatus, and using this vacuum-heating method.

Since vacuum-fusion is the method generally accepted as reliable, and has for a long while been employed in these laboratories with great confidence, a careful comparison with results obtained by this method has been kept throughout the investigation; the same-sized samples were used throughout ($\frac{1}{2}$-in. cylinders, $\frac{1}{4}$-in. long). The possible error due to the "blank" in the vacuum-fusion apparatus was higher than was desired (sometimes amounting to 0·00005 per cent. of hydrogen on the metal sample). However, differences between the results by the two methods were, for a while, greater than this, even when the vacuum-heating method was operating under what were found to be the optimum conditions. The reason for this, we are sure, was not due to error in either method, but rather to segregation of the hydrogen in different parts of the metal, or else to the loss of hydrogen resulting from the sample getting too hot during machining. Samples which had a normal hydrogen content were found to give a somewhat lower value if during machining the piece became too hot to handle, or still more so if there was any temper-colouring produced upon the surface. Small steel castings were found to vary considerably in their hydrogen content at different parts, and much of our earlier perplexities were connected with this fact.

A comparison of the results by the two methods for a number of metal samples indicates that there appears to be a tendency for the vacuum-fusion method to give slightly higher results than the vacuum-heating method. The reason for this appeared to be that the heating treatment had not extracted all the hydrogen, but the fact that several samples, on vacuum-fusion subsequent to vacuum heating, gave no further evolution of hydrogen discredits this view. When full allowance for the experimental error of each method was made, it was found that the accuracy of the heating method is ten times that of the fusion method. The temperature of operation for the heating method was 600 deg. C., excepting for the aluminium-alloy samples, which were found not to give off their hydrogen until they were actually molten. These aluminium-alloy samples were therefore inserted in small slip-cast alundum

* Paper read before the Iron and Steel Institute on Thursday, May 2, 1940. Abridged.

* See Eighth Report on Heterogeneity of Steel Ingots: Iron and Steel Institute *Special Report No.* 25 (1939).

THE ESTIMATION OF HYDROGEN IN STEEL.

Fig. 1.

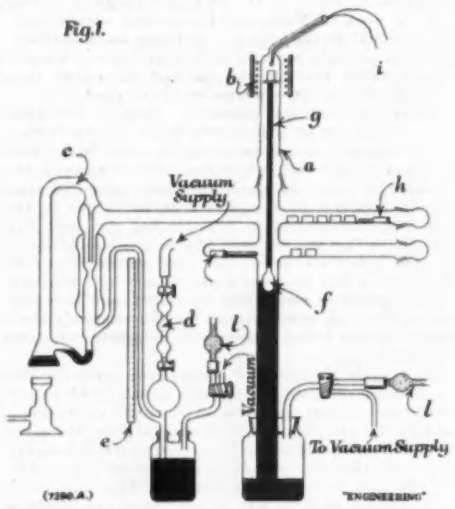
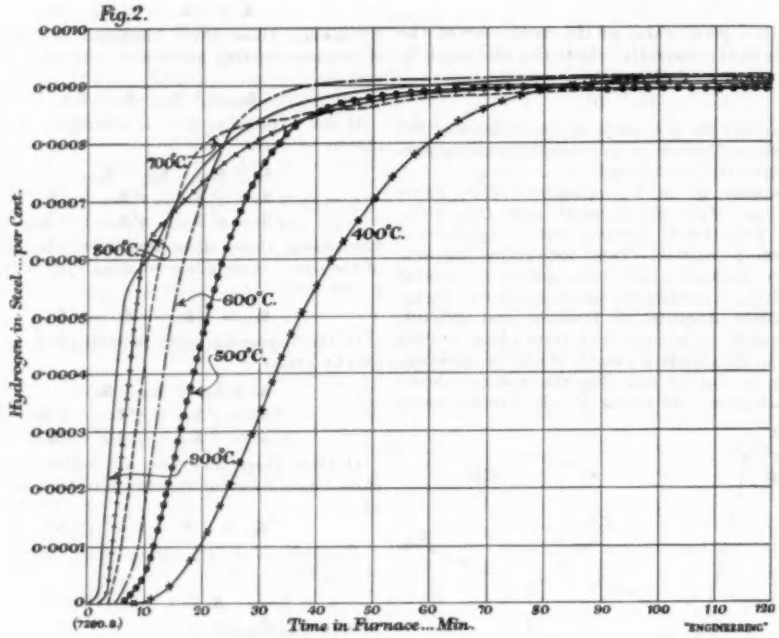


Fig. 2.



thimbles, in which they were melted in the furnace at about 700 deg. C., cooled out of the furnace and when solid again manipulated in their thimbles as solid metal samples. The rôle of hydrogen as a possibly deleterious constituent of metals is well recognised, and this apparatus not only has its applications in this direction, but also for the study of gas-metal equilibria, and the solution and diffusion of hydrogen in alloys.

Description of the Vacuum-Heating Apparatus.—In Fig. 1, on this page, is seen a diagrammatic sketch showing the working principles of the apparatus. The heating furnace *a* is a fused clear-silica tube round the upper end of which a well-lagged nickel-chromium resistance heating coil *b* is wound. This silica tube has a ground joint at its lower end, which fits a corresponding Pyrex-glass tube leading to a glass mercury-vapour pump *c*. For convenience this mercury-vapour pump is also in Pyrex glass, so that from the silica-joint onwards the apparatus through which the gas has to pass is in one piece, the mercury-vapour and the Töpler pumps having been sealed-on in position. The mercury-vapour pump is connected, via quill glass tubing, to a combined Töpler pump and McLeod gauge, the function of which is both to collect the gas and measure its quantity. The upper portion of this pump (which is called a Töpler pump for convenience) is joined to three small calibrated bulbs *d*, isolated by taps, into which the gas collected can be compressed and its volume and pressure recorded, by taking the height of the mercury in the adjacent vertical tubing, *e* being a pressure scale. These bulbs are graduated, the upper one being smaller than the middle one, which is itself smaller than the lower one, so that considerable variations in volume of gas can be dealt with. About seven-eighths of the gas collected is swept up and compressed by one operation of the Töpler pump, so that, in order to save time in taking readings of gas quantity, only one sweep of the pump was normally taken, and the precise factor, to convert this quantity measured to the total gas given off from the specimen, was experimentally determined.

A striking feature of the apparatus is the mercury lift used to move the samples vertically in and out of the furnace. A sealed glass bulb *f* floats upon the mercury surface in the central glass tube, and supports a long steel rod *g* on the top of which a steel platform is attached to support the metal samples. The position of this platform together with its sample is determined by the pressure in the bottle on the right-hand side of the sketch. Thus, by a turn of the three-way tap, either to the atmosphere or else to the vacuum supply, the platform can be brought to :—(1) The level of the upper horizontal tube containing unexamined metal samples, for the purpose of a sample being magnetically pushed on the platform, *h* being a magnetic ram ; (2) the level of the centre of the furnace, near which is a thermocouple *i* for the purpose of recording the temperature ; and (3) the level of the lower horizontal tube, into which the metal sample is magnetically pushed after its heat treatment, *k* being another magnetic ram. In Fig. 1, *l*, *l* are calcium-chloride tubes. This mode of performing mechanical operations *in vacuo* with the aid of mercury surfaces, controlled externally, has proved valuable, and superior for the present purpose to the purely magnetic control at first employed.

Preliminary Experimental Work : The Composition of the Gas.—The experiments of others indicated that under certain conditions gas other than hydrogen could be given off from metals on heating, so that in the original form of this apparatus an activated-charcoal pocket was sealed in between the furnace and the mercury-vapour pump. This was employed as a quick means of determining the actual amount of hydrogen as well as the amount of other gas, since in a high vacuum charcoal does not absorb any permanent gas unless the temperature is artificially lowered, when, at the temperature of liquid air, all gases except hydrogen are absorbed. The method of examining the gas was, therefore, to measure the quantity which passed through the charcoal pocket when surrounded by liquid air ; this gave the hydrogen value. Then by removing the liquid air and allowing the charcoal to warm up to room temperature, any increase in the reading corresponded to gas other than hydrogen. On several occasions the total gas collected was removed to a gas-analysis apparatus and analysed, but this was not considered a necessary part of the research, since it was hydrogen with which we were primarily concerned. Water vapour was invariably a constituent of the gas collected, unless the metal samples used were very bright and clean—and even then they came out of the apparatus brighter than when they went in. Where the quantity of water vapour was considerable, small droplets of water were visible in the Töpler pump during the compression of the gas. The simplest method used for detecting water vapour, when the quantity of it present was small, was to observe the pressure of the gas when it was compressed to different stages. Any departure of the product of the pressure and the volume from being a constant indicated water vapour. Since the presence of water vapour was invariably associated with a brightening-up of the surface of the metal, it is reasonable to assume that the water vapour was produced by a reduction of an oxide film by the hydrogen being evolved from the surface. However, in such a reaction :—

$$FeO + H_2 \rightarrow Fe + H_2O,$$

the volume of the water vapour formed is equal to the volume of hydrogen oxidised, so that, provided that no water is actually condensed out in the form of liquid, the volume of the system remains unaltered by the reaction. Hence all the metal samples were very carefully cleaned before examination, and the gas evolved was not unduly compressed.

Under all the conditions of study the gas given off from the steel was substantially hydrogen, but at temperatures above 700 deg. C. small amounts of carbon monoxide and nitrogen made their appearance, particularly the latter. As the temperature was raised the quantities of these gases evolved increased, and at a temperature of 1,000 deg. C. nearly 10 per cent. of the total gas was accounted for in this way. It will be noted that the apparatus was designed so as to avoid contact between the metal samples and the heated silica furnace tube, since it has been suggested that oxidation of carbon from steel can take place in this way. Certainly the quantity of carbon monoxide found was small, and the most which was collected at a temperature of 1,000 deg. C. only corresponded to 0·0008 per cent. of oxygen in the steel so treated. Nitrogen was given off in somewhat larger quantities at these higher temperatures, and for the sample just referred to the nitrogen corresponded to 0·003 per cent. of nitrogen in the steel. The total nitrogen content of this steel, as shown by vacuum-fusion, was only 0·008 per cent., so that a substantial proportion had been driven off from the solid.

The Effect of Temperature.—Temperature readings were obtained by a thermocouple and recorder, the thermocouple projecting down towards the centre of the furnace. The metal sample and platform were brought up close to the thermocouple, and the uniformity of the temperature was checked by bringing the metal sample into contact with the thermocouple, when no change in the reading was observed. At the higher end of the temperature range the temperature of the thermocouple and the sample were found to be closely the same when using a disappearing-filament pyrometer. The effect of temperature upon the rate of evolution of hydrogen was studied using a steel sample somewhat high in the gas, since it was thought that if the gas was present in the steel in different forms, then such a study ought to give evidence of the fact. Actually no such evidence was obtained. A number of samples were cut from closely adjacent positions in an ingot, and were raised into the furnace at different temperatures, the hydrogen given off being measured at frequent intervals of time. It was found that gas was rapidly given off at temperatures above 500 deg. C., the initial lag being reasonably accounted for as the time required for the sample to be heated. Above 900 deg. C. the rate of evolution of hydrogen was so rapid that accurate readings could not be obtained quickly enough, while below 400 deg. C. the rate became distinctly slow.

The conclusion of importance which was reached was that the total amount of hydrogen given off from the steel was independent of the temperature to which the steel was heated—this will be seen from the graphs reproduced in Fig. 2—and that this amount was equal to the amount given off by vacuum-fusion. It will be observed from these graphs that at temperatures above 700 deg. C. the curves show an irregularity which causes them to cross. The most likely explanation of this phenomenon is that on passing through the Ac_1 point the liberation of the hydrogen is in some way hindered. After it had been shown that no further evolution of hydrogen occurred when steel samples, which had already been vacuum-heated, were melted *in vacuo*, the conditions of extraction were standardised at 600 deg. C. for 1 hour. These conditions have been proved satisfactory for many different types of steel, but occasionally it is found that hydrogen is still being very slowly evolved after the period of 1 hour. If this occurs, then the period of heating is extended, maybe to 2 hours or more, until a constant value is obtained. No explanation of this effect can as yet be given, though it is thought to be possibly related to the influence of the structure of the steel upon the diffusion of hydrogen.

RESEARCH LABORATORIES: HIGH DUTY ALLOYS, LTD.

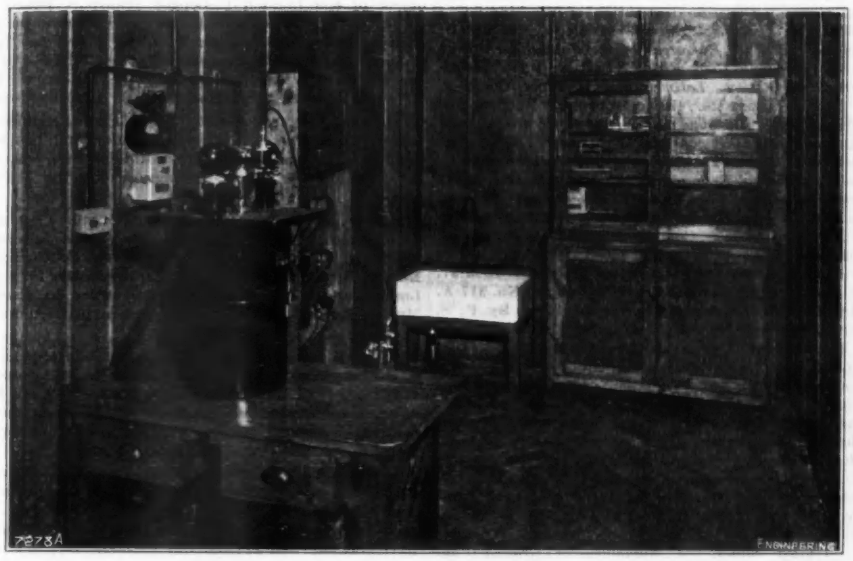


FIG. 1. X-RAY CRYSTALLOGRAPHIC LABORATORY.

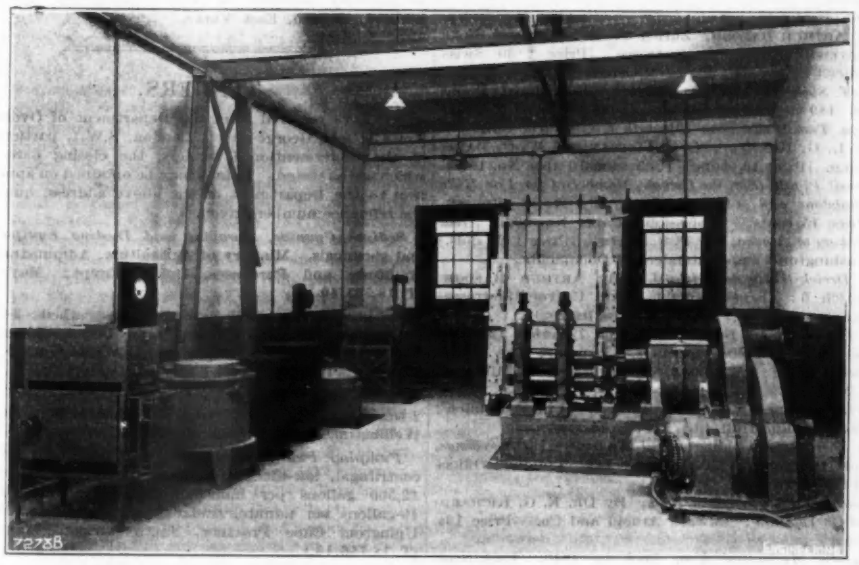


FIG. 2. HEAT-TREATMENT DEPARTMENT.

THE RESEARCH LABORATORIES OF MESSRS. HIGH DUTY ALLOYS, LIMITED.

IN recent years, the improvements which have been made in the performance of aircraft have, to a great extent, been due to increasing reliability in the components of both the machines and their engines, and this reliability, in turn, has been largely the result of systematic research and of the very high standards set up for the testing and inspection of their products by the metallurgical firms concerned. In pursuance of this policy and in the belief that progress, generally, in the light-alloy industry is inseparably bound up with scientific research, Messrs. High Duty Alloys, Limited, have maintained research and testing laboratories since the establishment of the firm in 1927. At first these laboratories consisted of two small rooms having a total floor area of 550 sq. ft., but frequent extensions were made subsequently to keep pace with the growth of the factories. Finally, the construction of entirely new research laboratories was decided upon and building operations commenced about a year ago. The laboratories, which were completed and occupied recently, were officially opened on April 30 by Sir Henry Tizard, K.C.B., F.R.S., F.R.Aë.S. In his speech of welcome to Sir Henry, Mr. W. C. Devereux, managing director of Messrs. High Duty Alloys, Limited, stated that when the firm was established, five persons were employed in the laboratory and seven in the other departments of the works. Undoubtedly, what success the Company had achieved had been entirely due to the attention paid to research, and, at the present time, the proportion of research workers employed amounted to 15 per cent. of the number of workpeople in the factory.

The new laboratory buildings occupy a floor space of 45,000 sq. ft., which, we understand, is more than four times the total area of the entire factory in 1928. The buildings comprise four bays, each of which has a length of 140 ft., and a span of 50 ft. Along the front of the bays is a two-storey block of administrative offices, while, at the rear of the bays, are arranged a number of outbuildings housing the air-conditioning plant, stores and cloak rooms. The four bays are subdivided into various departments by hollow brick walls, and as all the rooms are on the ground floor natural roof lighting is available in every department. The first bay contains the library, lecture theatre, spectrographic rooms, corrosion-research laboratory, and the instrument workshop, and the second bay the X-ray crystallographic laboratory and that for determining the damping capacity of materials, the microphotometry rooms, the colorimetric laboratory, the experimental testing laboratory, and the metallography department. The third bay contains a spacious chemical laboratory, a smaller laboratory for chemical-research work, and a balance room and stores for chemicals; while the fourth bay includes a heat-treatment department and a foundry for experimental work, and a mechanical-testing laboratory and an X-ray department, both of the latter being for routine work.

The spectrographic department, the principal room of which is seen in Fig. 3, on page 484, is equipped with two medium quartz spectrographs and with four microphotometers for the measurements of spectrum-line densities by means of photo-cells. In this department, the routine analysis of a considerable proportion of the aluminium alloys produced in the works is carried out—in particular, the analyses for magnesium, silicon and iron, and, at the present time, some 300 melts are examined each day. The equipment installed in the corrosion-research laboratory, a general view of which is given in Fig. 4, on page 484, includes a continuous sea-water spray booth, intermittent sea-water spray cabinets, apparatus for testing the resistance of materials to erosion, and a special apparatus for the alternate immersion in corrosive media, and free suspension in air, of specimens of alloys. This last piece of apparatus, which is driven by an electric motor, is seen on the left in Fig. 4. Plant for the deposition of protective coatings includes anodic and chromate-treatment baths; apparatus for the electro-deposition of copper, brass, cadmium, zinc, nickel and chromium (seen on the right in Fig. 4); and facilities for the spraying of paints and rubber. The instrument workshop is fitted up with machine and hand tools for the construction and maintenance of special research and laboratory equipment and for the manufacture and calibration of the thermocouples employed in the works.

In the X-ray crystallographic laboratory, a portion of which is shown in Fig. 1, on this page, X-ray methods are used for the determination of the extent and effects of cold-work and of crystal orientation in cast, worked, and heat-treated samples of industrial materials, and problems relating to the recrystallisation, grain growth and grain size of alloys are under investigation. In the adjoining "damping laboratory" investigations into the damping capacity of materials are conducted by means of electro-acoustic apparatus. This enables the damping capacity of large and small test specimens and manufactured components to be determined from the rate of decay of free oscillations, as well as from the half-amplitude breadth of the resonance curve. This laboratory is lined throughout with metal sheets to exclude all forms of electrical interference. A comprehensive programme of research is being undertaken, with the two-fold object of determining the damping capacity as a physical constant of a material in a given condition, and of using this property to give an indication of the state of the material in a component—notably with regard to strain, internal stresses and internal flaws. Next to the damping room is the colorimetric laboratory, which is equipped with several types of sensitive spectro-colorimetric instruments. A technique for the rapid and accurate measurement of the absorption of monochromatic light in a given length of test solution has been developed, and routine methods for the quantitative analysis of the iron and titanium contents of light alloys are now being introduced.

The experimental physical testing laboratory is to fulfil two distinct, though allied, functions. On the one hand, long-range research in a number of directions is to be conducted in it, and, on the other hand, the equipment provided will enable high-accuracy static and dynamic mechanical tests to be carried out. Obviously, therefore, the plant will vary somewhat from time to time, according to the type of research in progress, but, at present, the equipment includes two high-temperature vacuum furnaces of special design. One of these is a 20-kW high-frequency induction furnace, the other furnace being of the electrical-resistance type. The mechanical-testing equipment comprises an Avery 15-ton beam-type tensile-testing machine, two Amsler Wöhler-type and an N.P.L. rotating-type fatigue-testing machines, a battery of creep-testing machines, and an Avery Brinell hardness-testing machine. Adjoining this laboratory is the metallography department. This contains a main examination room, two smaller rooms for the preparation and polishing of specimens, an etching room, a photographic studio, and two large dark rooms. The equipment of the department includes a Vickers projection microscope, a Zeiss Neophot microscope and Beck bench microscopes.

As indicated above, the general and research chemical laboratories occupy the whole of the third bay of the building. They are equipped to carry out 500 complete analyses each day. As will be clear from the view given in Fig. 5, on page 484, considerable attention has been paid to the question of cleanliness and, to this end, the floors are of acid-resisting tiles and the walls are tiled right up to the roof, while the benches are provided with white Vitrolite tops. Special precautions have been taken in regard to ventilation, and besides the normal air-conditioning arrangements common to the whole building, which provide 20 changes of air per hour, a special fume-extraction plant has been installed in this department, capable of effecting 130 changes per hour. This plant, besides extracting air from the fume cupboards and at a point

near the roof level, has extractors arranged along the surface of each of the eight working benches and at floor level. A separate room, shown in Fig. 6, on page 484, is provided for the routine determination, by electro-chemical methods, of copper and other metals in alloys. The apparatus, seen on the right in Fig. 6, comprises 50 separate units, each having an independent totally-enclosed anode-rotating motor, transformer, rectifier, and electrically-controlled and heated hot plate. We understand that 150 determinations can be made per hour with this apparatus. The balance room, situated between the general and research chemical laboratories, contains 24 analytical balances.

The experimental heat-treatment department, a portion of which is shown in Fig. 2, on page 481, is equipped with two Wild-Barfield and one Siemens electric resistance furnaces of the forced air-circulation type, and with a number of electric muffle furnaces. Some of these units are seen along the left wall in Fig. 2. These furnaces are capable of being accurately controlled by connecting them to a single instrument panel, upon which are mounted sensitive potentiometric temperature controllers and recorders. The instruments on this panel can also be connected to furnaces in the works, so that it is possible to keep an accurate check on heat-treatment operations if necessary. Installed in the department is a small electrically-driven rolling mill, seen on the right in Fig. 2, which is employed for a variety of experimental purposes, including the preparation of experimental wrought-alloy specimens and the study of their hot- and cold-working characteristics. In close proximity to the rolling mill, and also visible in Fig. 2, is a billet-heating furnace fitted with pedal-operated doors. The heat-treatment department, together with the experimental foundry, make the new laboratory independent of the works in the matter of the provision of materials for primary research. The equipment of the foundry consists of various types of gas-fired and electric-resistance melting furnaces and an arc furnace. The main melting units are arranged in a pit along one side of the foundry, the tops of the furnaces projecting just above the level of the floor. Over these and over the casting floor are fitted canopies connected to the fume-extraction plant. The activities of this department include the preparation of experimental alloys, the investigation of casting properties, the development of casting methods and technique, and the study, development and control of moulding sands. The equipment of the routine mechanical-testing laboratory, which adjoins the foundry, includes three Amsler hydraulic universal testing machines, two of which are of 15 tons and one of 30 tons capacity, a 4-ton capacity Avery sheet-testing machine, and Brinell-hardness and other testing machines.

In recent years, as is well known, radiological inspection methods have exerted an important influence on the quality of metallurgical products. This method of non-destructive testing is now included in the inspection of all highly-stressed cast components made by the firm, and the apparatus provided in the X-ray routine department of the new laboratory is particularly complete. The equipment includes Philips X-ray tubes operating at 100, 150 and 200 kV, each housed in a separate lead-lined cubicle. All the controls are situated outside the cubicles, in separate rooms, in order to protect the operators. A notable feature of this department is a screening table equipped with a conveyor-belt system, whereby castings are fed on to the belt and pass under a viewing screen for examination. Remote control is provided by means of which the operator can manipulate the castings under the screen into any required position and can maintain them in position until he is satisfied as to their soundness. Unsound castings are marked by means of a dye, the jet of which is also remote controlled.

Throughout the new laboratory the services are self-contained and are independent of the works supplies of gas, electricity, water, and compressed air. All mains are carried in trench systems, enabling the services to be extended and permitting inspection or repairs to be carried out quickly and easily. The building was constructed by Messrs. Y. J. Lovell and Son, Limited, 6, Bathurst-street, W.2, and the architect was Col. A. L. Abbott, F.R.I.B.A.

PATROL LAUNCHES FOR GOVERNMENT OF BURMA.—A fleet of five patrol launches is to be built in Rangoon for the service of the Government of Burma. Construction will be carried out to designs supplied by Messrs. John I. Thornycroft and Company, Limited, Thornycroft House, Smith-square, London, S.W.1, from whom the propelling machinery has also been ordered. The launches will have a length of 77 ft., and a beam of 13 ft. 6 in. Two of the vessels will each be fitted with one 12-cylinder, 650-b.h.p. petrol engine, and two 6-cylinder, 145-b.h.p. Diesel engines, while the propelling machinery of the three other launches will consist of three 145-b.h.p. Diesel engines in each case.

BOOKS RECEIVED.

Carnegie Institution of Washington. Annual Report of the Director of the Department of Terrestrial Magnetism. Washington: Carnegie Institution of Washington.

United States Geological Survey. Bulletin No. 874-D. *Geology and Fuel Resources of the Southeastern Part of the Oklahoma Coal Field.* Part 4. *The Howe-Wilburton District, Latimer and le Flore Counties.* By T. A. HENDRICKS. [Price 70 cents.] Bulletin No. 906-A. *Gravel and Sand Deposits of Eastern Maryland Adjacent to Washington and Baltimore.* By N. H. DARTON. [Price 1·25 dols.] Bulletin No. 906-B. *Geology and Coal Resources of the Minot Region, North Dakota.* By D. A. ANDREWS. [Price 50 cents.] Bulletin No. 909-D. *Geophysical Abstracts.* No. 95. *October to December,* 1938. Compiled by W. AYVAZOGLOU. [Price 15 cents.] Bulletin No. 916-A. *Transit Traverse in Missouri.* Part I. *Southeastern Missouri,* 1903-37. By J. G. STAACK. [Price 20 cents.] Bulletin No. 917-A. *The Mineral Industry of Alaska in* 1938. By P. S. SMITH. [Price 35 cents.] Washington: Superintendent of Documents.

The Ohio State University. The Engineering Experiment Station. Bulletin No. 103. *Nepheline Syenite in Ceramic Wares.* By C. J. KOENIG. Columbus, Ohio, U.S.A.: The Director, The Engineering Experiment Station, The Ohio State University. [Price 40 cents.]

United States Geological Survey. Water-Supply Paper No. 836-C. *Artesian Water Levels and Interference Between Artesian Wells in the Vicinity of Lehi, Utah.* By G. H. TAYLOR and H. E. THOMAS. [Price 15 cents.] Water-Supply Paper No. 836-D. *Ground Water in the United States. A Summary of Ground-Water Conditions and Resources.* By O. E. MEINZER. [Price 15 cents.] Washington: Superintendent of Documents.

Fluchtlinientafeln mit Rechteckigen Verbindungsgeraden. By ARTHUR BALOGH. Zürich 6: Ernst Wurzel, Ecke Universitätstrasse-Tannenstrasse. [Price 2·50 Swiss francs.]

United States Geological Survey. Professional Paper No. 189-G. *Foraminifera, Diatoms, and Mollusks from Test Wells near Elizabeth City, North Carolina.* By L. G. HENBEST, K. E. LOHMAN and W. C. MANSFIELD. [Price 10 cents.] Professional Paper No. 189-I. *Fossil Plants from the Colgate Member of the Fox Hills Sandstone and Adjacent Strata.* By R. W. BROWN. [Price 15 cents.] Professional Paper No. 192. *Areal Geology of Alaska.* By P. S. SMITH. [Price 1·25 dols.] Washington: Superintendent of Documents.

Die Dreick-Hexagonalnetztafel. By ARTHUR BALOGH. Zürich 6: Ernst Wurzel, Ecke Universitätstrasse-Tannenstrasse. [Price 2·50 Swiss francs.]

The B.S.P. Pocket Book. Tables and Technical Information on Pile Driving Operations. London: The British Steel Piling Co., Ltd., Thames House, Millbank, S.W.1.

Aircraft Engines. Volume I. By A. W. JUDGE. London: Chapman and Hall, Ltd. [Price 16*s.* net.]

The Institution of Mechanical Engineers. Proceedings. July-December, 1939. Volume 142. London: Offices of the Institution.

Sound. A Physical Text-Book. By DR. E. G. RICHARDSON. London: Edward Arnold and Co. [Price 16*s.* net.]

Calvert's Mechanics' Year Book for 1940. Park-road, Timperley, Altrincham: Sherratt and Hughes. [Price 6*d.* net.]

United States War Department. Lake Series No. 8. *The Ports of Sandusky, Huron, and Lorain, Ohio.* [Revised 1939.] Washington: Superintendent of Documents. [Price 1 dol.]

The Law Relating to Building and Engineering Contracts. Third edition. By W. T. CRESWELL, assisted by N. P. GREIG. London: Sir Isaac Pitman and Sons, Ltd. [Price 16*s.* net.]

Working Model Railways. By E. F. CARTER. London: Percival Marshall and Co., Ltd. [Price 1*s.* 6*d.* net.]

THE LATE MR. F. H. EDWARDS.—We regret to record the death of Mr. Frederick Henry Edwards, which occurred on Tuesday, April 16, at the age of sixty-two. After being educated at the Kilburn Grammar School and the Regent-street Polytechnic, London, Mr. Edwards began his professional career in 1898, when he was appointed shift engineer to the Hampstead Electric Supply Company. After holding similar positions with the Stepney Borough Council and the London United Tramways, he became deputy electrical engineer to the Woolwich Borough Council, and subsequently was deputy electrical engineer and tramways manager at Erith and deputy electrical engineer to the Cornwall Power Company. In 1919, he was appointed engineer and manager of the Dartford Corporation Electricity Department, a position he was still holding at the time of his death. Mr. Edwards was elected an Associate Member of the Institution of Electrical Engineers in 1906 and transferred to the class of Members in 1922.

PERSONAL.

CONSEQUENT upon the retirement of MR. FRANK PICK from the posts of vice-chairman and chief executive officer of the London Passenger Transport Board on Friday, May 17, the office of chief executive officer has been abolished and the work of the Board has been divided into eight departments. One of these will be concerned with engineering, and will be under MR. V. A. M. ROBERTSON, M.Inst.C.E., as engineer-in-chief.

MR. B. C. BAYLEY, M.B.E., chief electrical engineer of Messrs. John Player and Sons, Nottingham, has been nominated chairman of the East Midland Sub-Centre of the Institution of Electrical Engineers for the 1940-41 session.

MESSRS. YALE AND TOWNE MANUFACTURING COMPANY, Wood-street, Willenhall, S. Staffs, have appointed MR. H. L. E. WORKMAN, 85, Pershore-road South, King's Norton, Birmingham, to be their representative for North London and the northern Home Counties, in place of MR. A. BRANT, who has been given a position in the works.

MR. E. H. CLIFFORD, A.R.S.M., M.Inst.M.M., consulting mining engineer to the British South Africa Company, 2, London Wall Buildings, London Wall, E.C.2, has been appointed an additional member of the departmental committee concerned with the production of non-ferrous metal ores in the United Kingdom.

MESSRS. THE BRITISH OXYGEN COMPANY, LIMITED, Thames House, Millbank, London, S.W.1, inform us that MESSRS. THE QUASI-ARC COMPANY, LIMITED, and MESSRS. THE FERRO-ARC WELDING COMPANY, LIMITED, have amalgamated as from May 1.

MR. N. BILES has left the employ of Messrs. G. and J. Weir, Limited, Cathcart, Glasgow, and is now engaged as publicity manager of Messrs. Blackburn Aircraft, Limited, Brough, East Yorks.

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Sodium Cyanide, Spraying and Dusting Equipment, and chemicals. Ministry of Agriculture, Administration of Stores and Purchases, Dokki, Egypt; May 27. (T. 18,561/40.)

Telephone Cable, textile covered, lead-sheathed: 9-pair, two miles; 15-pair, 6 miles; and 20-pair, 1½ miles. Post and Telegraph Department, Wellington, N.Z.; May 28. (T. 18,695/40.)

Copper Binding Wire, 3 tons, 60 lb. per mile, and 2 tons, 50 lb. per mile. Post and Telegraph Department, Wellington, N.Z.; May 29. (T. 18,697/40.)

Pumping Plant, comprising four electrically-driven, centrifugal, low-lift pumps, each capable of delivering 12,500 gallons per hour; and one vertical-spindle, 40-gallons per minute, sludge pump. Municipality of Upington, Cape Province, South Africa; May 29. (T. 18,756/40.)

Bare Cadmium-Copper Wire, to B.S.S. No. 175, 50,000 lb. Union Tender and Supplies Board, Pretoria; May 30. (T. 18.976/40.)

Dust-Extraction, Air-Cooling and Ventilation Plants for cantonments at Peshawar, Kohat, Nowshera and Lahore. Indian Stores Department, Mechanical Section, New Delhi; May 21. (T. 19,085/40.)

Lead-Rolling Mill. With reference to the call for tenders for a lead-rolling mill, noted on page 436, *ante,* we now learn that the Postmaster-General's Department, Melbourne, has extended the closing date to June 4. The date originally fixed was April 30. (T. 17,070/40.)

Oxygen Cylinders, also demi-johns, bottles and jars. Ministry of Public Health, Cairo, Egypt; June 4. (T. 18,961/40.)

India-Rubber Tubing, also bottles, rubber caps for bottles, and corks. Ministry of Public Health, Cairo, Egypt; June 11. (T. 18,963/40.)

Brushes and Painters' Tools. Ministry of Education, Cairo, Egypt, June 12. (T. 18,966/40.)

Locomotive Boilers, one for a 4-6-0, one for a 4-4-2, and six for 4-4-0 broad-gauge engines; also one for a 4-6-2 and one for a 0-6-2 metre-gauge engines. General Manager, Eastern Bengal Railway, Calcutta; June 27. (T. 18,502/40.)

Circuit Breaker, 11,000-volt, outdoor-type, oil-immersed. Public Works Department, Wellington, N.Z.; June 25. (T.Y. 18,700/40.)

Supervisory Control Equipment for the remote control of switchgear and transformers at Mount Roskill sub-station from Penrose substation. Public Works Department, Wellington, N.Z.; July 16. (T. 19,161/40.)

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—In all branches larger outputs are reported. The demand for raw and semi-finished materials is substantially greater than six months ago, and many works have extended their melting capacity. In an effort to keep pace with orders, some concerns will continue operations throughout the Whitsuntide holiday, while others will take advantage of the break to carry out urgent repairs to furnaces. While it is true that scrap supplies have been somewhat erratic, no difficulty has been experienced in obtaining sufficient tonnages of hematites and pig-iron from the North East Coast. Makers of heavy types of machinery, equipment, and engineering products are operating at high pressure. Orders are on hand for the supply of hollow forgings and boiler drums in connection with extensions to power stations in various parts of the country, and the recent run on steelworks' and ironworks' machinery and similar equipment has been maintained. Among the lines in demand are rolling mills, hydraulic presses, shearing machines, and lathes. Inquiries at works producing agricultural machinery and parts show that the season has so far exceeded expectations; many farmers having renewed their machinery and implements. The tool trades continue to be exceptionally busy. Overseas needs are expanding, the Dominions and Colonies in particular being good customers. File makers are busy, and report that sales to Spain, at one time one of Sheffield's best foreign customers, are increasing.

South Yorkshire Coal Trade.—A slight improvement is reported in the export market, and the inland position is strong. Industrial fuel is in keen demand. Steam coal is selling well, while locomotive fuel is in better request. Considering the season, the house coal market is satisfactory.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Much activity continues in the Scottish steel trade and the production generally is at a maximum. The requirements of the shipbuilding industry have reached a large tonnage and the allied trades are pressing for supplies. Structural sections are going rapidly into consumption and the tonnage on order is considerable. The raw material position is satisfactory. Export business has improved, licences being granted more freely. Black-steel sheets are still in great demand. Prices are steady and are as follows:—Boiler plates, 13*l.* 8*s.* per ton; ship plates, 12*l.* 10*s.* 6*d.* per ton; sections, 12*l.* 8*s.* per ton; medium plates, under $\frac{5}{16}$ in. thick, weighing 6 lb. or more per square foot, 14*l.* per ton, and weighing under 6 lb. but not less than 4·81 lb. per square foot, 14*l.* 10*s.* per ton; black-steel sheets, No. 24 gauge, in 4-ton lots, 17*l.* 10*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, in 4-ton lots, 20*l.* per ton, all delivered at Glasgow stations.

Malleable-Iron Trade.—There has been little change in the West of Scotland malleable-iron trade during the past week and, with a steady output, the current demand is being met. The re-rollers of steel bars have a large amount of work on hand and the mills are kept running at full capacity. Good supplies of semies have recently been received from overseas and the prospects of regular supplies is favourable. The following are the current quotations:—Crown bars, 14*l.* 2*s.* 6*d.* per ton; No. 3 bars, 12*l.* 10*s.* per ton; No. 4 bars, 12*l.* 15*s.* per ton; and re-rolled steel bars (tested), in 4-ton lots, 14*l.* 3*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—In the Scottish pig-iron trade the output is being maintained at the highest possible level. As the makers of small castings are busier there is a better demand for foundry grades of iron. To-day's market prices are as follows:—Hematite, 6*l.* 7*s.* 6*d.* per ton, and basic iron, 5*l.* 4*s.* 6*d.* per ton, both delivered at the steelworks; foundry iron, No. 1, 5*l.* 15*s.* and No. 3, 5*l.* 12*s.* 6*d.* per ton, on trucks at makers' yards.

PERIODIC USE OF SUMMER AND WINTER TIME.—In a recent issue of *Comptes Rendus*, M. E. Esclangon points out that the midday of clocks should also mark the middle of the day, but this is impossible for two reasons. The actual midday varies with the longitude over France and the introduction of summer-time has made an arbitary change. Custom makes "morning" to mean the time between rising and midday of the clocks, and "afternoon" the time between this and dinner time. These two intervals are very unequal. The author urges that the maximum of daylight would be available if the months of October and March were used for changing from and to summer time. He suggests further that in Paris the day should begin at 6 a.m. and, if summer time were introduced on the proposed date, the nominal hours of the day would be 7 a.m. to 7 p.m.; and they would all be included in daylight. Similarly, with November 1 for winter time, the daylight hours would nominally be from 7 a.m. to 6 p.m.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Although outputs of iron and steel remain near the record level, every effort is being made to increase production. The control of distribution system promises eventually to ensure deliveries to destinations where supplies are most needed, and while the demand for material for war-time requirements is still unabated, a narrowing margin of tonnage is available for ordinary industrial purposes.

Cleveland Iron Trade.—For some time stocks of foundry iron have been virtually exhausted, but supplies are maintained on a scale that meets consumers' requirements. The local output is confined to the intermittent make of substitutes for the numbered qualities of Cleveland pig and is too light to contribute materially to current requirements, but the delivery of tonnage from the Midlands continues to be regular and ample. Stabilised quotations of Tees-side qualities remain on the basis of No. 3 description of Cleveland at 111*s.* delivered within the Middlesbrough zone.

Hematite.—Producers of East Coast hematite, though turning out heavy tonnages, are experiencing difficulty in keeping pace with the large and increasing requirements. The tonnage stored at the blast-furnaces has shrunk considerably, but although the statistical situation may necessitate an early enlargement of the make, by bringing additional plant into operation, makers expect to be able to deal successfully with the position. The consuming works owned by hematite producers are absorbing increasing quantities of iron, and buyers, who are pressing for deliveries against extensive running contracts, are also desirous of placing substantial new orders. The recognised market values remain at the level of No. 1 grade of hematite at 127*s.* 6*d.*, delivered to North of England areas.

Basic Iron.—Makers of basic iron continue to use the whole of the large output at their own steelworks, and the quotation of 104*s.* 6*d.* is nominal.

Foreign Ore.—Consumers of foreign ore are fairly well placed as regards stocks and also expect to receive adequate supplies.

Blast-Furnace Coke.—Conditions in the Durham blast-furnace coke branch of trade are unchanged. As local users are well covered and holders are disinclined to add to their contract obligations, business is quiet. Fixed prices are ruled by good medium qualities at 31*s.* 8*d.* at the ovens.

Manufactured Iron and Steel.—The deliveries of semi-finished iron and steel are on a scale sufficient for the heavy requirements of re-rollers. Finished-iron firms have a considerable amount of work on hand, but are booking further orders. Producers of finished steel continue to run their plant at full capacity in order to comply with customers' requests for increased supplies and the contracts they have to execute cannot be completed before the end of the allocation period on June 30. Hope is expressed that favourable consideration will be given to applications for permission to deal with the balances in the third quarter of the year.

Scrap.—Deliveries of iron and steel scrap are on a somewhat improved scale, but the demand is as urgent as ever.

THE ROYAL SOCIETY OF ARTS.—We are informed that the entries for the March and May examinations of the Royal Society of Arts have totalled 31,230.

ANNUAL REPORT OF THE INSTITUTION OF ELECTRICAL ENGINEERS.—We are asked to state that copies of the Annual Report of the Council of the Institution of Electrical Engineers for 1939-40 and of the accounts for the year ended December 31, 1939, can now be obtained by members on application to the Secretary, Savoy-place, Victoria-embankment, London, W.C.2.

NATIONAL SAFETY CONGRESS.—The National Safety First Association, 52, Grosvenor-gardens, London, S.W.1, is holding a one-day National Safety Congress in London on Friday, May 17. The keynote of Congress is safety measures in war time, and, included in the industrial section programme is an address by Mr. A. W. Garrett, H.M. Chief Inspector of Factories, who will deal in a general way with war-time safety problems in factories. The Congress will then turn its attention to a detailed consideration of the main problem, which relates to the rapid increases in the numbers employed. In the morning, under the chairmanship of Lord McGowan, the President, Mr. B. Ungerson will read a paper on "How to Train New Employees in Safety." In the afternoon, Sir Duncan Wilson will be in the Chair, and Mr. H. Malin will deal with "Specific Teaching for New Employees Concerning Machine-Tool Hazards." After lunch there will also be an address by Sir John Anderson on "War-Time Safety Measures Affecting Education Authorities and Industrial and Transport Undertakings."

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF MECHANICAL ENGINEERS.—Friday, May 17, 6.30 p.m., Storey's-gate, Westminster, S.W.1. Informal Meeting. Exhibition of Industrial Cinematograph Films.

ROYAL INSTITUTION.—Friday, May 17, 9 p.m., 21, Albemarle-street, W.1. "A Great Calculating Machine," by Professor D. R. Hartree.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Price increases, affecting all grades of Welsh coals, were announced on the Welsh steam-coal market during the past week, to take effect immediately. All steam coals for export were advanced by 1*s.* per ton, while the pithead price to inland consumers was increased by 8*d.* In the case of anthracite descriptions, the price for export was advanced by 2*s.* per ton and 1*s.* 8*d.* at pithead for home consumption. House-coal prices at the pits were advanced by 8*d.* per ton, in common with other steam coals for inland use, but in view of the recent increase of 10 per cent. in railway delivery charges, it was estimated that the delivered price would be up by about 1*s.* 8*d.* per ton. Arrangements for a census of the unemployed in the coalfield were completed by the Executive Council of the South Wales Miners' Federation. This will take place during the next fortnight, its object being to ascertain the number of workers unemployed not only in the coal-mining industry itself, but including also former colliery workers who have transferred to other industries. The result will be submitted to a meeting of the South Wales Joint Production Committee. The demand was actively maintained on the market throughout the week. The present productions of the collieries were almost entirely earmarked for contract deliveries, and order books were sufficiently well filled to ensure that the position will not be materially altered for some time to come. The general tone was consequently very firmly upheld. Duff coals remained the strongest feature of the market; there was a brisk request for these sorts, but business was impossible over several months ahead. Sized and large descriptions were well provided with outlets over the next few months, while smalls were again only sparingly offered. Cokes were active and strong.

The Iron and Steel Trade.—Active conditions continued in the iron and steel and allied industries of South Wales and Monmouthshire last week. The works were kept fully employed in fulfilling orders already on hand, and the demand was well maintained. Order books are well filled over some time ahead.

THE ROYAL SANITARY INSTITUTE.—In order to economise paper, the Council of the Royal Sanitary Institute has decided to issue its *Journal* quarterly instead of monthly, after the completion of the present volume in June.

THE STEEL INDUSTRY IN THE UNITED STATES.—The production of steel ingots in the United States, during the first week in April, is stated to have been equivalent to 60·9 per cent. of the potential capacity of the steel plants. During the previous week it was 61·3 per cent., while during the corresponding week of 1939 it was 50·9 per cent., and that of 1938, 32·4 per cent.

THE THOMAS GRAY MEMORIAL TRUST.—The Council of the Royal Society of Arts announces that a prize of 50*l.*, under the Thomas Gray Memorial Trust, for "the advancement of the science of navigation and the scientific and educational interests of the British Mercantile Marine, will be awarded to any person who may bring to the notice of the Council "an invention, publication, diagram, etc., which in the opinion of the judges is considered to be an advancement in the Science or Practice of Navigation," proposed or invented by himself during the period from January 1, 1935, to December 31, 1940. Entries which have been already considered in the years 1935 to 1939 are not eligible for further consideration unless they have since been materially modified. The competition is open to persons of any nationality. Proofs of claim must be forwarded to the Secretary, the Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2, on or before December 31, 1940, from whom the full particulars of the competition may be obtained. Notice is also given that an award of 12*l.* 10*s.* 0*d.* has been made to Dr. S. C. Blacktin, of Leeds, for his direct-view particle counter and portable ultra-microscope; and awards of 7*l.* 10*s.* 0*d.* each to Mr. Digby Jones, of Liverpool, and Mr. J. Joshua Daniel, of Wirral, Cheshire, for their essays on "The Carriage of Dangerous Goods by Sea."

RESEARCH LABORATORIES OF MESSRS. HIGH DUTY ALLOYS, LIMITED.

(*For Description, see Page* 481.)

FIG. 3. SPECTROGRAPHIC ROOM.

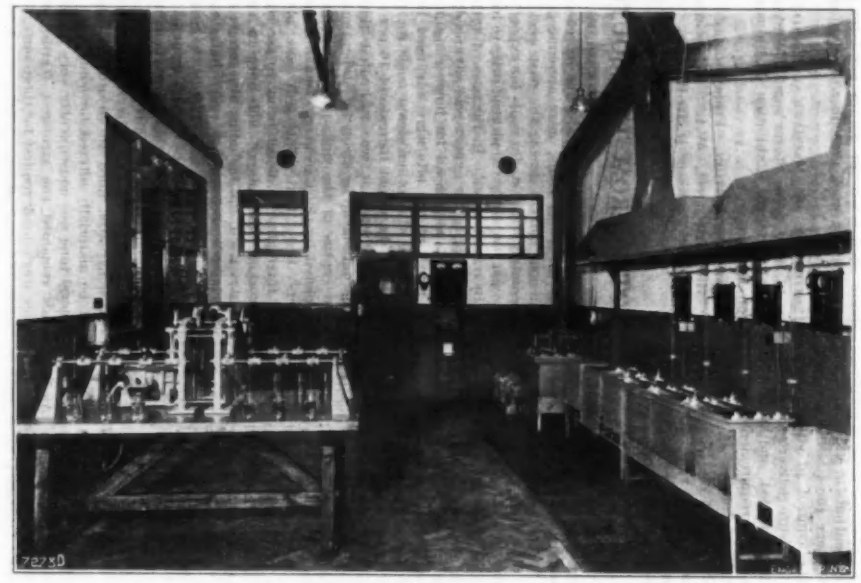


FIG. 4. CORROSION-RESEARCH LABORATORY.

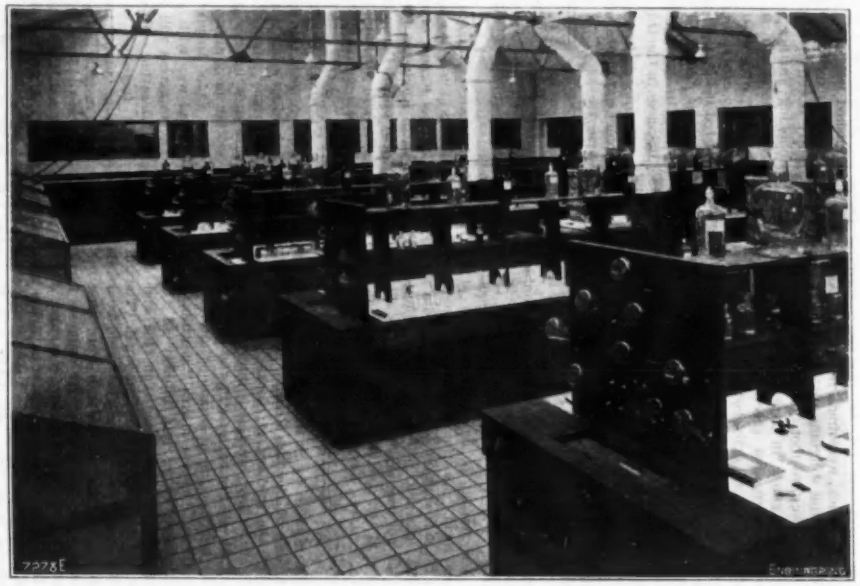


FIG. 5. GENERAL CHEMICAL LABORATORY.

FIG. 6. ELECTROLYTIC LABORATORY.

REPAIR BY WELDING OF A FRACTURED CAST-STEEL HYDRAULIC CYLINDER.

MESSRS. INTERNATIONAL COMBUSTION, LIMITED, LONDON.

(*For Description, see Page* 475).

FIG. 1. CRACKED HYDRAULIC CYLINDER.

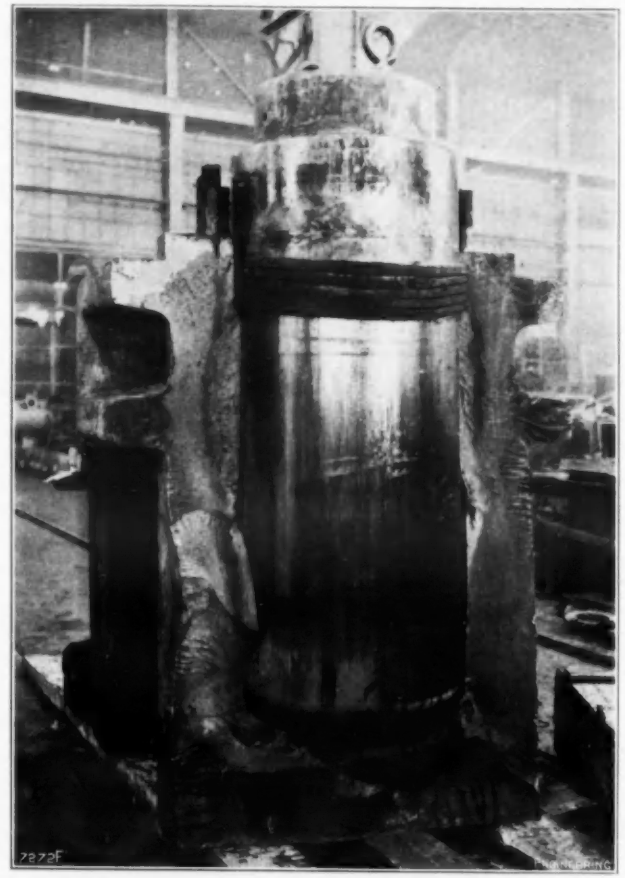
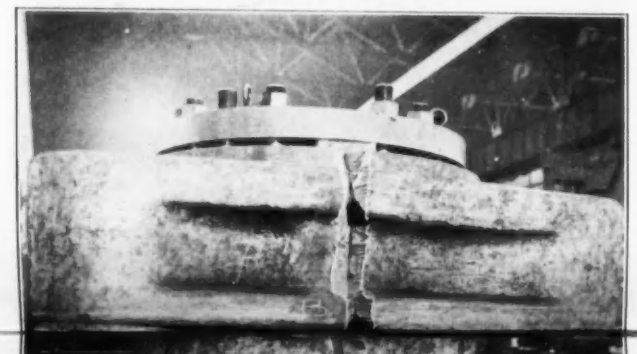


FIG. 2. SEIZED RAM IN CYLINDER.

FIG. 3. DRILLING TO RELEASE RAM.



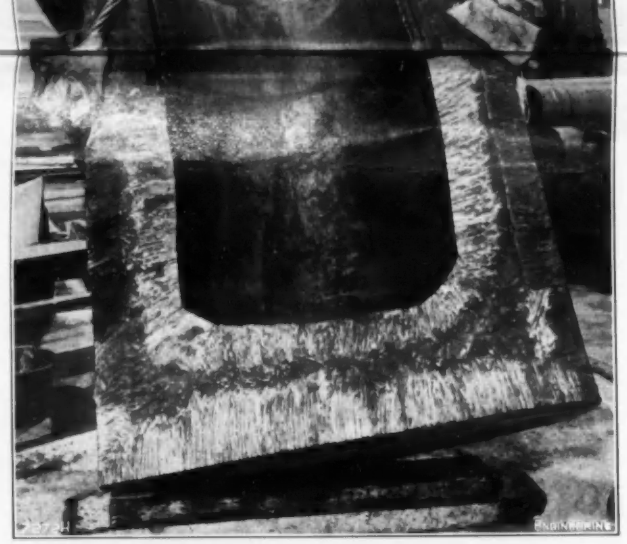


FIG. 4. HALF CYLINDER PREPARED FOR WELDING.

FIG. 5. CYLINDER ASSEMBLED FOR WELDING.

FIG. 6. WELDING OF FRACTURE IN PROGRESS.

FIG. 7. PARTIALLY-COMPLETED WELD.

FIG. 8. BORING CYLINDER FOR LINER.

FIG. 9. COMPLETED CYLINDER.

UNIV. OF MICH.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of Publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, MAY 10, 1940.

VOL. 149. No. 3878.

TRANSCONTINENTAL TELEPHONY.

UNTIL a few months ago it was possible for a telephone subscriber in this country to speak to 97 per cent. of the other telephone subscribers in the world. Included in this figure were practically the whole of those in Europe and the North American continent, as well as subscribers living in parts, at least, of Australia, New Zealand, South Africa and South America. Further, communication with certain ocean liners could be established and even some tracts of Asia were not excluded. During recent years, too, communication between subscribers in these islands has been much extended and improved. Not only is it considerably better in quality than it was a comparatively short time ago, but, as far as long distances are concerned, it can be effected with a rapidity which, a decade ago, was confined to operation between contiguous areas. War, however, has temporarily interrupted further progress ; and although the telephone subscriber in this country has not much to grumble about, it is clear that the facilities he enjoys may be considerably curtailed if frightfulness from the air breaks out. For the time being, his telephonic *Lebensraum* is practically confined to his own country, and his freedom to communicate with other lands is severely limited. This is but a passing phase, of course, and after hostilities cease the old facilities will be restored. Opportunity may even be taken to add such others to them as the skill and ingenuity of the engineer may render possible.

That being so, it is not so inopportune as might appear at first sight to call attention to a review of "A Quarter Century of Transcontinental Telephony," which has recently been contributed to *Electrical Engineering*, the publication of the American Institute of Electrical Engineers, by Dr. F. B. Jewett, and particularly to emphasise one or two points which may become of increasing importance in the future. It is, perhaps, hardly necessary to say that the continent with which Dr. Jewett deals is the United States and that he, as technical head of the American Telegraph and Telephone Company, has been largely responsible for the work which he describes. It may be mentioned, also, that, thanks to the close relationship which exists between that concern and the Engineering Department of the British Post Office, most of the improvements that have been carried out in the States have been paralleled in Great Britain and that the engineers of neither country would wish to claim that they have priority, either in inventiveness or application.

As Dr. Jewett points out, it was twenty-five years ago last July that the first transcontinental circuit was inaugurated, and twenty-five years ago last January since the first transcontinental line, which consisted of three circuits, was opened for public use. For purposes of comparison, it may be recalled that, at the same date, in this country, to speak from London to Glasgow (a distance only a fraction of that involved in the American exploit) was an undertaking requiring an expenditure of much time, necessitating a great strain upon the patience, and frequently producing merely mediocre results. The only cities on the Continent with which telephonic communication was possible were Paris and Brussels, and then under conditions which were wasteful of time and trying to the temper.

The reasons for this may be explained by describing the technical position in 1914. A long-distance telephone line then consisted of a pair of large copper wires strung in the open, with magnetic loading coils spaced along them at intervals of eight miles. Amplifiers were unknown, to all intents and purposes. The circuit operated, therefore, upon the principle that no energy which had not been introduced at the sending end came out at the receiving end. The losses were naturally high, and the problem was complicated by the necessity of preserving enough energy at the various frequencies represented by speech to ensure that intelligibility was not sacrificed. Under these conditions, with a loaded line consisting of No. 8 gauge hard-drawn copper wire, it was just possible to carry on a conversation between New York and Denver. This line had an equivalent loss of about 35 decibels, so that only about 1/4,000 of the power introduced at the transmitting end emerged at the receiving end. As a transcontinental line designed on the same basis would have yielded only 1/400,000 of the original power at the receiving end, it was obvious that some system of amplification at intermediate points was essential, since the use of heavier circuits would have been economically unsound. After many years of research, the solution of this problem was found in the use of the thermionic valve, which in the period under review has not only changed from a fragile piece of laboratory apparatus to an engineering product, but has completely revolutionised the technique of long-distance telephony.

As Dr. Jewett indicates, one of the changes brought about by the valve was to alter the design of the line : instead of considering the necessity to minimise the energy loss at every smaller point and smaller diameter wires could be used merely on considerations of simplicity and first cost. Another alteration was that the loading coil was deposed from its position of paramount importance as a conserver of telephone current. Loading, of course, always had disadvantages, and where, as on the first transcontinental line, it had to be lavishly employed, its use resulted in a serious degradation of the speech quality. Incidentally, it was the discovery that the more heavily loaded the line, the narrower the band of frequencies which could be transmitted, which led to the construction of the wave filter.

A feature of the first transcontinental line was the inclusion of three repeater units at Pittsburgh, Chicago and Denver, respectively. These, when supplemented by heavy loading, were just sufficient to make the circuit usable. As, however, the width of the effective band of speech frequencies was only about 900 cycles, compared with the 2,500 cycles in use to-day on ordinary circuits, and the 7,500 cycles employed in broadcasting, the quality of the speech left much to be desired. Three more repeaters were, therefore, inserted in the system, which, in conjunction with heavy loading, gave a gain of about 40 decibels, compared with a line loss of 60 decibels. The result was a line with about the permissible minimum of commercial speech quality. Gradually the number

of repeaters was increased until it was possible to remove the loading coils altogether, this step being dictated by a desire to increase the quality of the speech and to meet the rising traffic demand by creating more circuits. With this end in view, too, carrier systems were superimposed on the original lines, thus increasing the number of channels from three to nine.

Another important change resulted from the introduction of the amplifier. This was the substitution of cables for open wire circuits. Without the amplifier the cable was impracticable for circuits of any length, owing both to distortion and attenuation; but with it the advantages of stability, freedom from breakage and from inductive disturbance possessed by the cable became manifest, especially when the traffic density was large enough to warrant the provision of a number of separate circuits. In fact, the provision of facilities only awakened the appetite for more, with the result that the number of long-distance messages increased from 12 million in 1913 to some 55 millions in 1938. According to Dr. Jewett, unquestionably the most important factors in stimulating this growth in demand were the increased convenience, reliability, speed of service and quality of speech reproduction. Speed of service especially has received attention, strenuous efforts having been made to reduce to a minimum the delay experienced by the calling subscriber before he is placed in communication with the called party. This had meant not only the provision of additional circuits, but the development of superior operating technique and more direct routing.

The outcome of all this development has been the institution of a toll switching plan. This involves the division of the country into areas, within which a small number of important switching points, known as "primary outlets," are provided. Each toll centre, or important exchange, is connected to one or more of these outlets and the outlets themselves are directly interconnected. In this way, any two toll centres within an area can be interconnected with a maximum of two switches, and, within the part of the area served by one primary outlet, with a maximum of one intermediate switch. Direct lines are also provided between toll centres when the traffic justifies this course. The primary outlets have been selected, of course, after a careful study of the operating conditions, so that their number is a minimum, consistent with handling the traffic economically. The result is that the switching for 2,500 centres in the United States and Canada has been greatly improved by the establishment of about 150 of these as primary outlets. In addition, eight of the largest cities between New York in the east and San Francisco in the west have been designated as regional centres and each primary outlet is connected to at least one of these. Each regional centre is also connected to at least one other regional centre. Any primary outlet, of which there are 150, can be connected, therefore, to any other with a maximum of two intermediate switches, and within the area served by a regional centre with a maximum of one intermediate switch. As an illustration of the concentration that results, it may be mentioned that New York serves as a regional centre for the entire north-east portion of the United States as well as for eastern Canada. Chicago, too, is another important centre, from which direct lines radiate to important cities in the neighbouring states. In this way a very complete network has been built up, which enables the traffic to be handled both expeditiously and efficiently and is capable of development as circumstances require. One possible ultimate development that is suggested is the increasing connection of primary outlets to a single regional centre at Chicago. This city would, of course, be the natural selection owing to its geographical position; and it is interesting to note that it is already directly connected to more than half the existing primary outlets. The effect of all this is to decrease the differences in the methods of handling local and trunk calls, and it is significant that over 90 per cent. of the trunk calls can now be completed while the subscriber remains at the telephone. The same trend was noticeable in this country before war broke out, but it is evident that we have still a good deal of leeway to make up.

COKE-OVEN DEVELOPMENT.

The production of coke in the by-product coke-oven has become one of the major industries of the country, and in the present circumstances it is of vital importance to the nation. The supply of coke to the metallurgical industries is a prime essential in the maintenance of the national war effort, and the export market is by no means a negligible factor on the economic side of the war. Fortunately, the coke-oven industry has entered the struggle very well equipped, and while there is still some way to go before every works is completely modernised, it can be declared with confidence that the position is immeasurably better than in 1914. At that time, not less than one-third, and possibly one-half, of the total metallurgical-coke production came from the old beehive or other non-recovery ovens; to-day, these have almost disappeared. Of the by-product ovens then in existence, a number did not recover benzole, and all were of small capacity, requiring a great deal of labour; to-day, the majority of the ovens at work are of high capacity, the plants are so mechanised that labour has been reduced to a bare minimum, and the average benzole production over the whole industry is 3¼ gallons per ton. During the last war, the Ministry of Munitions had to take special steps to encourage the production of benzole, a task which has not to be faced in this war. In the last six years the iron and steel industry has been modernised and with it has proceeded the modernisation of the coke-oven industry. It has long been advocated that the function of the coke-oven in a modern iron and steel works is to treat all the fuel that enters the works, dividing it into coke, gas, and by-products, each of which can then be put to its best use. In this way great reductions are possible in the fuel consumption of blast-furnaces and steel-making plant.

One result of the last war was to render it evident that future safety depended upon the provision of large atmospheric-nitrogen fixation plants, which could manufacture fertilisers in times of peace and explosives in time of war. In the outcome, ammonia ceased to be a profitable by-product from carbonisation, and the economics of the coking industry were gravely prejudiced. Gas was then discovered to be a profitable by-product, although previously it had been sold for, perhaps, 3*d*. per 1,000 cub. ft., or even less, for firing boilers. There was difficulty in selling all the gas to the town's-gas industry, and its utilisation in open-hearth and re-heating furnaces provided an adequate and profitable outlet, a fact which became the more obvious after the report of the Departmental Committee which investigated the proposal to set up the South Yorkshire Gas Grid. This gas grid, incidentally, has proved to be of outstanding value under present conditions and is making a notable contribution to the national effort. It is being followed, as even at that time many thought it should be, by a gas grid in North Yorkshire, fostered by the gas industry through the United Kingdom Gas Corporation. It would not be surprising if other gas grids were found practicable, particularly on the North-east coast.

In the past six years, no less than 1,774 ovens have been erected, with a total capacity of about 11,000,000 tons of coal per year, and of these, 28 plants, having an annual capacity of 9¾ million tons of coal, or an output of just over 6½ million tons of coke, have been erected at the steel plants. Thus, to a large extent, the steel plants are self-contained. It has been estimated that the coke-producing capacity of steelworks coking plants is 7,600,000 tons of coke per year, and, according to the official publication, *Statistics of the Iron and Steel Industry*, this is almost exactly equal to the coke consumed at the blast-furnaces during 1938, and is within 2,000,000 tons of the maximum coke consumption yet recorded, that of 1937. In normal times, therefore, comparatively little furnace coke remains to be supplied by the colliery-owned coke ovens. The proprietors of colliery-owned ovens have now come to the conclusion that the advocacy of properly-organised marketing schemes is justified; and coke-oven owners are forming coke-marketing organisations that are based, to some extent, upon the model of the Coal Utilisation Council. Before the war, some 4,000,000 tons of oven coke were sold in the general market, less, perhaps, in competition with gas coke than in conjunction with it. The gas-coke interests in the south of England have organised the trade so that merchants and producers alike constitute a common body which functions to the advantage of all by looking after the best interests of the consumer. This organisation has been copied latterly by the gas interests in other parts of the country. There is a Midland and Counties Coke Association, based on Birmingham, a Lancashire and District Coke Association, an Association for the Yorkshire Area, and a North-East Coast Association.

The coke-oven owners have not been idle. Most of them are keenly interested in the new movement, and district arrangements have been made with the gas interests. On the north-east coast, a "gentleman's agreement" governs the price of coke in the general market. In one district the marketing of coke has been carried a stage further, and an organisation known as the Coke Producers' Federation, Limited, has been established with its headquarters in Sheffield, this being the only complete organisation of its kind within the coking industry. Care is taken to avoid overlapping with existing similar organisations in other parts of the country. This Federation is working in co-operation with the London and Counties and the Midland and Counties Coke Associations. Price arrangements have been made with the Yorkshire Commercial Section of the Manchester and District Association of Gas Engineers, and negotiations are proceeding with the coke distributors in Yorkshire. It is to be expected that working arrangements for the control of prices will be made to cover the whole area, and will include both producers and distributors. As coke for blast-furnaces is already covered by the national tripartite agreement between the iron and steel producers, the foundry owners and the coke producers, the situation in this area is developing satisfactorily. It is to be hoped that a similar development will take place in other areas, and that it will include the provision of technical assistance. The Coke Producers' Federation has set up a technical department, modelled on that of the gas-coke associations, through which difficulties that may arise in the utilisation of oven coke in any part of the country can be investigated, technical assistance can be given to the merchants and distributors, new uses for coke developed, and, the general market encouraged by giving expert service to the consumer. The policy of the coke-oven industry is guided now by the Association of Coke and Bye-Products Plant Owners, and the advantage of having a united body to speak on behalf of the industry is widely recognised. There are a few "die-hards" who are not yet convinced that co-operation is better than individualism in this particular field, but this attitude is against the general trend of industrial organisation, and it seems likely that, before long, the whole of the by-product coking plants in the country will be united in the one association.

The annual report of the Midland Coke Research Committee serves as a reminder that, with all this technical and commercial development, research has not been neglected. It is evident that the coking industry now has two main objectives. One is to produce the best possible quality of furnace coke; the other is to produce a suitable coke for the domestic market and for the many minor industrial uses that are being developed by the coke-marketing organisations. Research must be directed, therefore, to the furtherance of both these aims. In some districts, such as the North-East Coast, blast-furnace coke is still the major product, and it will be so in all districts while the war lasts. The Midland Research Committee however, has recognised that it has also the duty of looking after the interests of those who produce for other markets, and an attempt has been made to balance the work to that end. Two volumes by Dr. Mott and the late Professor Wheeler, *Coke for Blast Furnaces* and *The Quality of Coke* (the latter of which was reviewed in Engineering on page 30, *ante*) described the research work of this body prior to 1929 and from 1929 to 1937, respectively. The annual reports thereafter indicate upon

what lines the work has since proceeded. In general, the outstanding result of the work of the Midland Committee has been the proof that the non-coking constituents of coal play a vital part in determining the quality of the coke produced from a particular coal. This was already known, in a general way, because coals having what may be termed an excess of coking energy were known to benefit by being blended with poorer coking coals or with coke dust. The hard, dull constituent of coal, durain, is known to be practically non-coking. The present report records that differences in the behaviour of commercial grades of coal, when crushed to a uniform size, can be attributed to differences in durain content; though the influence of the fusain—the completely non-coking, woody fibrous material in coal—to which attention was drawn in previous works (*loc. cit.*) must not be neglected. Durain up to 50 per cent. has a beneficial effect on the shatter index of the coke, whatever the rank of the coal; but when in excess of 50 per cent., it has an adverse effect on the abradability when the bright coal (vitrain and clarain) is of low rank or low carbon content. On the other hand, the adverse effect on the abradability of high durain content in coals of high rank is so small that cokes of foundry quality can be made from their crushed hards.

Tests made in blast furnaces on the practical scale were cut short by the war, but it has been possible to deduce without reasonable doubt that, when using coke of high shatter test, "the furnace drove more regularly at fast and slow rates, and with a lower coke consumption and a lower blast pressure," than with other cokes of lower shatter test. The length of the period over which slag-forming materials accumulate is important in judging the true coke consumption for any coke, for the furnace has a low coke consumption when these materials are accumulated, and is deranged if a sudden release occurs. The assertion, frequently made, that the hard Cleveland ore requires a coke of higher minimum Cochrane abrasion index than a soft Lincolnshire ore, has been tested by putting the ore, the coke and mixtures of coke and ore through the abrasion drum test. It was claimed that the Lincolnshire ore was much less abradable than the Cleveland ore, which provided some compensation for the fact that Midland cokes are weaker than Durham cokes. The evidence provided by the committee's work does not support this assertion.

Work has also been in progress upon the dangerous swelling pressure of certain coals which destroy oven walls. This subject was exhaustively treated in a paper* by Dr. G. E. Foxwell, delivered to the Institute of Fuel last year. The work of the Midland Committee has been directed to an examination of certain small-scale empirical methods of detecting dangerous coals, as a result of which they have concluded that these coals are not widespread in this country and are confined to certain low-volatile varieties of high rank, generally having a calorific value, on the dry, ash-free basis, in excess of 15,700 B.Th.U. per pound. The committee agree with the already known principle that the swelling propensities of these coals can be controlled by reducing the bulk density of the charge in the coke ovens. Certain work in progress on the prediction of the coking power of coals from the volatile-matter proportion of the calorific value, appears likely to lead to a practical rule for assessing the probable coking power of coals from laboratory tests. On the domestic coke side, the committee have completed a large-scale trial showing that the method of alkali-activation reduces the combustibility of coke to an adequate extent. By heating a non-coking coal of low rank at a fast rate in an experimental oven, the yield of breeze was reduced to 10 per cent. and the coke, though not of metallurgical quality, proved to be excellent for the domestic grate. The work of this committee, while perhaps yielding no results likely to change coking practice fundamentally, is of considerable value in assessing the correctness of the views put forward from time to time within the industry, and in placing the technical aspects of coke production upon a sound scientific basis.

* See ENGINEERING, vol. 147, page 344 (1939).

NOTES.

"ENGINEERING" AND THE PAPER SHORTAGE.

THE announcements made recently in the daily Press, and confirmed by the reduced size of all newspapers and the disappearance of so many of the familiar contents bills, have fully informed the general public of the severe restrictions now imposed on the consumption of ordinary "newsprint"; but it may not be so well appreciated that even the finer-quality papers used in the production of the less ephemeral periodicals are affected to an equally serious extent. They are, however, subject (with a few relatively unimportant exceptions) to the same drastic scaling-down of supplies, and some explanation appears desirable, therefore, of the changes that must be made in the near future in the case of ENGINEERING. Already, as readers will have observed, a certain reduction has been made in the number of editorial pages, but this alone is far from sufficient to compensate for the latest cut in the quantity of paper available. Commencing with this week's issue, the number of pages has been further reduced to 20, and this figure will remain as a standard for the editorial contents until conditions permit of an increase. While present stocks last, the weight and opacity of the pages will remain unchanged; but the supplies of paper to individual journals are rationed on a basis of weight, not area, and we shall be obliged to use a thinner (and, consequently, rather less opaque) paper at an early date, in order to maintain even this reduced number of pages per week. It is hoped that the quality of the paper—a feature to which considerable attention has been devoted—will not be affected; but some sacrifice of appearance, unfortunately, is inevitable when a thinner paper is employed, as can be seen by comparing the ordinary thick-paper issue with the thin-paper copies which we have supplied for many years to postal subscribers overseas. We need hardly add that the normal weight and opacity will be restored as soon as circumstances permit. Certain other means of paper economy, also, are being adopted. Supplies of ENGINEERING to the wholesale and retail distributors are now made on a strictly non-returnable basis, so that the margin of copies available at bookstalls, etc., for sale to casual purchasers will be very small. It is desirable, therefore, and may be essential, to place a definite order with a newsagent, in order to ensure a regular supply. If this is done, no difficulty should be experienced in obtaining regular delivery. After the issue of May 24, no contents bills will be issued for display on bookstalls and elsewhere. The issue of complimentary and voucher copies to advertisers, etc., also, is being reduced to the minimum. All of these steps have been taken at the urgent request of the Paper Controller, and in full collaboration with our contemporaries of the technical Press. Taken together, we believe that they will be effective in reducing the weekly consumption to the limit prescribed, and that there will be no necessity to omit any of the usual features of the editorial contents.

EMERGENCY SUBSTATIONS FOR THE CENTRAL ELECTRICITY BOARD.

As already announced in ENGINEERING, certain precautions have been taken by the Central Electricity Board to ensure an early restoration of supply should damage be caused by enemy action to generating or substation equipment. These precautions consist of the establishment of a pool of transformers, switchgear, cables and overhead-line equipment, which can be readily transported in emergency to any place where they may be required. The transformers vary in capacity from 5,000 kVA to 30,000 kVA, and are suitable for all the main voltages in use in the country. They are stored complete with the cooling gear, bushings and conservators in position, and can be dispatched by either rail or road. On arrival, the only parts that require fitting are such brackets and insulators as are necessary to meet the actual site requirements, an operation which can be carried out in less than an hour. The cooling of transformers that exceed 10,000 kVA in output is effected by fans, the motors of which are driven from the secondary of an auxiliary transformer contained on the main unit. The switchgear is suitable for either 66 kV, 33 or 22 kV or 11 or 6 kV circuits, and has been designed so as to be capable of extremely rapid erection and for use both in and out of doors. A considerable degree of flexibility has also been attained, and the incoming or outgoing connections can be made either by cables or overhead lines. The cable is of the single-core type and is complete with all accessories. These include emergency joint boxes which are filled with special cold-setting compound. As cable jointing will take up a considerable portion of the time required to make the emergency supply available, the switchgear has been arranged so that those parts which require connection to the feeder circuits can be completed first and the cable men can then proceed with their work without interfering with the erection of the remainder of the substation. The overhead-line material is suitable for pressures ranging from 33 kV to 132 kV, and the necessary jumpers are provided to enable temporary connections to be made to the existing lines and the spare transformers and switchgear. As illustrating the short time in which such equipment can be brought into use, it may be mentioned that a 20,000-kVA, 33/11/6·6-kV transformer was recently transported from store to site, erected, connected to a four-bay switchboard, comprising one transformer switch and three outgoing circuits, and made alive in nineteen working hours.

ELECTRICAL INDUSTRY AND EXPORT GROUPS.

The reasons for the formation of export groups and the functions of these bodies were explained by Sir Clive Baillieu, executive member of the Export Council, to a gathering of representatives of the electrical industry, which took place at the Hotel Victoria, London, on Wednesday, April 24. The present situation, he said, had caused the Government to frame a policy for narrowing the growing gap between the volume of exports and imports. As a result of a preliminary survey, it was clear that, in world markets as a whole, there was a considerable measure of goodwill for British trade, but that the task of the exporter was being hampered by the increasing difficulties of quoting firm prices and deliveries. The fundamental difficulty, however, was that of raw materials, for unless there was an assured and expanding supply of these the export trade could not be maintained, much less extended. It was necessary to know what raw materials were available, so that they could be equitably divided, and the conclusion had been reached that, for this purpose, it was essential to bring industries together into organised groups, through which their demands could be co-ordinated. The first duty of such a group was to assess its needs for raw materials. The the industry, either directly or in association with the Industrial Supplies Department of the Board of Trade, must decide on the most equitable method of distribution. In addition, the group would deal with such matters as market problems, credit and labour. It would also have to assess plant capacity and to determine the proportions that were to be allocated to export, home and service needs. The electrical industry could help by making a close estimation of its requirements, so as to ensure the minimum diversion of plant and raw materials from export, as well as reducing wasteful competition and pooling resources.

COOPERS HILL WAR MEMORIAL PRIZE.—Founded by members of the Royal Indian Engineering College, Coopers Hill, in commemoration of their colleagues who fell during the war of 1914-18, the Coopers Hill War Memorial Prize is awarded annually by the Institution of Civil Engineers, and triennially, in turn, by the Institution of Electrical Engineers, the School of Military Engineering, Chatham, and the School of Forestry, Oxford. The prize, which consists of a bronze medal, a parchment certificate of award, and a money prize of the value of 20*l.*, is awarded for the best paper on a professional subject selected by the Council making the award. The triennial award falls this year to the Council of the Institution of Electrical Engineers, which has decided to invite corporate members under 35 years of age to submit for consideration a paper on any subject coming within the scope of "Electrical Science or Electrical Engineering and their Applications." Papers submitted must reach the Secretary of the Institution not later than October 1, 1940.

THE IRON AND STEEL INSTITUTE.

THE seventy-first annual meeting of the Iron and Steel Institute was held in the offices of the Institute, at 4, Grosvenor-gardens, London, S.W.1, on Thursday and Friday, May 2 and 3. Mr. James Henderson, senior vice-president, took the chair at the outset of the proceedings in the absence, owing to indisposition, of the retiring President, Lord Dudley. The first business was the presentation of the Report of the Council for the year 1939. This showed that the number of members on the roll of the Institute, on December 31 last, was 2,704, compared with 2,630 on December 31, 1938. The Council recorded with regret the deaths of 44 members which had occurred during the year; these included Professor Broniewski, Mr. A. Dreux, Mr. J. E. Fletcher, Mr. F. C. A. H. Lantsberry, Professor H. Louis, Professor A. Sauveur, Mr. C. M. Schwab, and Professor R. V. Wheeler. The outbreak of the war had had comparatively little effect so far on the normal activities of the Institute, but the issue of a monthly *Journal*, which it had been proposed to commence in January, 1940, had been postponed. The research activities of the Institute in conjunction with the Iron and Steel Industrial Research Council had assumed an additional importance, and were being actively prosecuted. The statement of accounts, prepared by Mr. Henderson as honorary treasurer, showed that both the expenditure and the income of the Institute had increased; expenditure, at 18,279*l.*, was greater by 2,472*l.* than it had been last year, and was 228*l.* in excess of income. The Council were gratified at the success of the appeal, launched by Lord Dudley in May, 1939, for a House Fund of 15,000*l.*, and for industrial subscriptions of not less than 4,000*l.* a year for a period of seven years. Over 13,000*l.* had been contributed to the House Fund, and industrial subscriptions of nearly 3,300*l.* had been received.

At this stage of the proceedings Mr. Henderson formally inducted the President-elect, Mr. John Craig, C.B.E., D.L., into the chair. The secretary then announced the names of members of the Council, who, having retired by rotation, were re-elected for a further period of office, no other nominations having been received. These comprised three vice-presidents, namely, Sir William Larke, K.B.E., Mr. A. O. Peech, and Dr. C. H. Desch, F.R.S., and five members of the Council, namely, Mr. E. J. Fox, Dr. T. Swinden, Dr. A. McCance, Mr. P. B. Brown, and Mr. J. R. Menzies-Wilson. Mr. Craig then presented the Bessemer Gold Medal for 1940 to Dr. A. McCance, and, in doing so, said that the award was in recognition of his great services to the scientific study of steelmaking problems, with special reference to the application of the rules of physical chemistry to the open-hearth process and his critical examination of the thermochemical equations governing the process. Among the monuments to his work were steelworks erected in Scotland, incorporating his own ideas, carried out by his technical staff. He had done much to place Scotland in a position to maintain worthily its place in the realm of steelmaking. In expressing his appreciation of the honour conferred upon him, Dr. McCance said that to have one's name associated with that of Bessemer, no matter in what degree, was the aspiration of all metallurgists. It must be admitted, he added, that the practice of steelmaking was still ahead of the theory, but the gap between them was lessening. Anything he had been able to do in the technical re-organisation of the steelworks with which he was associated could not have been done without the help and encouragement given by Mr. Craig.

The next announcement was to the effect that Mr. Eugène Schneider, D.Sc., had been elected an honorary member of the Institute, to commemorate the 50th anniversary of his becoming a member. He had served as President from 1918 to 1920 and had received the Bessemer Gold Medal in 1930; and it was largely with his assistance that meetings of the Institute had been held in France, Czechoslovakia and Luxembourg. The last three matters on the agenda, prior to the presentation and discussion of papers, were, firstly, the announcement of the award of an Andrew Carnegie Silver Medal to Mr. O. W. L. Ljunggren; secondly, the presentation of the Williams Prize jointly to Mr. W. B. Lawrie and to Mr. W. T. Wilson; and, lastly, the announcement that the Prize, for 1941, of 50*l.*, offered by Captain C. A. Ablett for a paper on a subject connected with engineering in iron and steel works, written by a junior engineer, was now open for competition.

PRESIDENTIAL ADDRESS.

Mr. Craig then delivered his Presidential Address, in which he dealt first with the developments that had taken place in the iron and steel industry in Scotland during the past 50 years, and then passed on to a consideration of some commercial aspects of the industry. After stating that the wasteful coal-fired, open-topped blast-furnace had given place to the modern furnace, producing in a day twice as much iron as the former had produced in a week, and that raw fuel had been practically eliminated from the steelworks, Mr. Craig stated that there had been, particularly in recent years, a remarkable development of co-operation and goodwill on the commercial side. An industry could find within itself ample scope for competition in the improvement of quality, service and economic production, and this surely interpreted competition on a greater and a finer basis than had formerly been the case. It was a policy which enabled an industry to enjoy the fruits of its labour by providing funds for constantly and steadily taking advantage of every improvement in plant and methods made known through increasing knowledge. When competition merely affected price, the industry was not in a position to take advantage of such improvements, so that, in the long run, it was better for the consumer to pay a reasonable price and rely upon the industry using a fair proportion of its profits to maintain its powers of production in an efficient condition. These were advantages which could not be associated with price cutting, and price control had, therefore, had to take its place. With the experience gained during the last few years, it did not appear that even consumers had any case against price control.

THE STRUCTURE OF ALLOYS.

The first paper considered was entitled "Researches into the Structure of Alloys," and was by Dr. A. J. Bradley, F.R.S., Professor W. L. Bragg, F.R.S., and Dr. C. Sykes. The contribution was presented to the meeting by Professor Bragg, who emphasised that while the equilibrium diagrams of alloys of two metals had been thoroughly explored by the older metallurgical methods, the application of X-ray analysis made possible an exhaustive study of alloys of three or more metals. This work, however, was only in the initial stages; there were so many combinations, even if experiment were restricted to the common metals, that it would take a long time to survey the field. Nevertheless, there were already indications of general laws, and of a theoretical explanation of the crystalline patterns which were formed when the metallic elements were alloyed in different proportions. Part I of the contribution, which was entitled "Investigation of Equilibrium Diagrams and Theory of Order-Disorder Transformation," dealt in particular with the X-ray analysis of binary and ternary systems with the component metals chromium, iron, cobalt, nickel, copper, and aluminium.

Speaking of structures of a submicroscopic order of magnitude, the authors stated that examples were accumulating of the possibility of exploring structures of the order of magnitude of 10^{-7}, 10^{-6} and 10^{-5} cm. by X-ray methods, not only in alloys, but in other complex structures, such as those of certain minerals. Structures of a magnitude of 10^{-4} cm., and larger, became visible under the microscope in polished and etched specimens. All instances of the order-disorder transformation so far discovered occurred in alloys which approximated in composition to the simple ratios A B or A B_3. The transformation was a "co-operational phenomenon." The ordered structure existed at low temperatures because it had a lower internal energy than the disordered structure. The phenomenon might be described as a simplified version of the melting of a crystal to form a liquid, the critical temperature being compared to a secondary melting point. When the alloy first crystallised from the melt, the atoms were arranged at random on the lattice points. At another temperature, below the melting point, a kind of second crystallisation set in and the atoms took ordered positions.

Part II of the paper, by Dr. Sykes, dealt with the experimental investigation of the order-disorder transformation, using the alloys β-brass, Cu_3Au, Cu_3Pd and Ni_3Fe. The values for the energy of the transformation were found to be in satisfactory agreement with those predicted by the theoretical treatments given by Bragg and Williams and other workers in this field. The thermal methods specially developed for the investigation were also employed to determine the specific heat/temperature curves of iron, nickel and a number of age-hardening alloys, and it was pointed out that the present X-ray technique appeared to be capable of deriving much useful information concerning the precise structure of hardened alloys. The experimental work already concluded had shown that the precipitate, in certain alloys, could be detected by X-ray methods at stages in the hardening process prior to maximum hardness.

Dr. W. H. Hatfield, F.R.S., who opened the discussion, emphasised the value of fundamental X-ray work on alloy structures. Some fifteen or sixteen years ago, when experimenting with austenitic rustless steels, he had found that as the result of cold work they attained great strength. At the same time, they ceased to be non-magnetic and became magnetic, while, however, remaining rustless. This was most mysterious, and as, at that time, there were no facilities for X-ray work of this type in this country, he had approached Dr. Benedicks, of Stockholm, who, at his first attempt, had shown that the steel became magnetic because the cold work "toppled over" the face-centred cubic system to the body-centred system. This knowledge had proved of distinct industrial value. A subsequent speaker, Dr. A. H. Jay, urged that the authors should give accounts of their work again and again, in different ways to suit different audiences of iron and steel technicians, engineers, chemists and physicists, until the potentialities of the X-ray method were understood as clearly as were those of chemical analysis or mechanical testing.

Dr. W. Hume-Rothery, F.R.S., who spoke next, commented on the distrust which existed to some extent between X-ray workers and those who employed the older methods. This was a pity, because each could contribute a great deal. The methods adopted by the authors for the preparation of their fine filings should have been given in their paper. The extreme reluctance which X-ray workers seemed to have in publishing full details of this kind was extraordinary. At Oxford, the analysis of fine filings had been found to consist of practically 100 per cent. of one phase. Special precautions were necessary, and it should be made known how far the authors, in preparing their diagrams, had relied on the assumption that the filings were of the same composition as the main lump of material.

Mr. D. A. Oliver said that the new X-ray and specific-heat technique constituted new research tools which must be used with discrimination and were powerful if suited to the work. The system iron-nickel-aluminium contained within its boundaries the Mishima class of permanent-magnet alloys, which it was almost impossible to investigate microscopically. The discussion was closed by Dr. C. H. Desch, F.R.S., who said that having seen, at first hand, the X-ray technique used by Professor Bragg and Dr. Bradley, he would like to emphasise that it was very far in advance of any used anywhere else in the world. It was by reason of that technique, together with the authors' theoretical grasp of the subject, that so great an advance had been made. He was, however, inclined to the belief that microscopic work was not so strictly limited as the authors had indicated. It was possible to see particles of the order of 10^{-5} cm., although he concurred that it was not possible to resolve very fine pearlite. In a very brief reply, Professor Bragg agreed fully with Dr. Hume-Rothery's remarks concerning the importance of collaboration between the various groups of workers, and agreed also that 10^{-5} cm. should be

substituted for 10^{-4} cm. as the limit of visibility under the microscope.

MANUFACTURE OF PIG IRON IN AMERICA.

The second paper considered by the meeting on Thursday morning dealt with "The Manufacture of Pig-Iron in America," and was by Mr. W. A. Haven. It was presented on his behalf by Mr. J. Henderson. At the outset, the author stated that his specific purpose was to describe the designs, equipment and practices which characterised practically all modern American blast-furnaces, notwithstanding some great differences in the nature of the raw materials employed in the principal producing districts. The chief pig-iron making areas in America were centred in Monterey, Mexico; Nova Scotia; the Southern or Alabama district; the Provo district in the Rocky Mountain State of Utah; the Eastern New York and Pennsylvania district; and the Mid-Western area. From the point of view of chemical analysis, the Lake Superior iron-ore fields provided a sufficient variety of ore for the manufacture of all the principal foundry and steel-making grades of pig iron, but not ferro alloys. The great bulk of the Lake Superior ores, however, was eminently satisfactory for the manufacture of foundry pig iron and of pig for use in making steel by the acid-Bessemer or basic open-hearth methods, which, in America, represented more than 90 per cent. of the total production. The Wabana ores of Newfoundland and those of Alabama were of "near basic-Bessemer" quality, but pig iron made from them in America was all converted into steel by the basic open-hearth process.

No commercial blast-furnace plant in the Middle West area, making ordinary grades of pig iron, had been able to survive without adjacent by-product coke-ovens, which, when situated in or near large centres of population, generally derived a substantial revenue from the sale of coke-oven gas and of household coke. In their interior dimensions, American furnaces were characterised by large hearth and top diameters, great overall heights and low, steep boshes. The dimensions of three 1,000-tons a day furnaces, designed and built in 1937-38, were indicative of the comparative uniformity of ideas, with regard to lines, in the three rather widely separated localities of Cleveland, Detroit and Chicago. A hearth diameter of 25 ft., and a height of 100 ft. had come to be considered almost standard requirements for an output of 1,000 tons a day from Lake ores, but recently there had been a tendency to still greater heights. The Republic Steel Corporation's Youngstown furnace No. 2 had been rebuilt in 1938, the new hearth diameter being 25 ft. 6 in. and the height 105 ft. During the present year a furnace, 108 ft. in height and having a 27-ft. hearth, would be built, and overall dimensions of 110 ft. by 30 ft. had recently been proposed. From every point of view large furnaces had justified themselves for American conditions. By reducing the number of stacks, operating costs as well as capital charges had been greatly lessened, while, metallurgically, the results had been beneficial almost without exception. The rates of coke consumption had been lowered, flue-dust losses had been diminished and pig-iron quality had been improved from the standpoints of composition and uniformity. Methods of blast-furnace operation had become more uniform as a result of crushing all ores to smaller sizes and the adoption, in other districts, of furnace lines and equipment which had been developed particularly for smelting the fine Lake Superior ores.

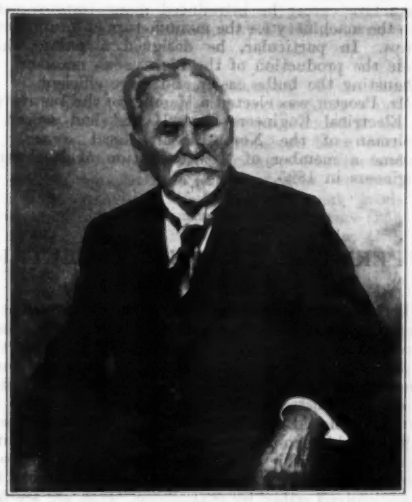
The only speaker in the discussion, Dr. T. P. Colclough, said that the author had emphasised that all new blast-furnaces built in America since 1933 had been of the 1,000-ton a day class, and that this procedure had been justified by increased output per stack. In this country and on the Continent the sizes of blast-furnaces had also been gradually increased of late years, and, with every step in this development, there had been increasing economy of operation. Furthermore, if we crushed, screened and sintered our ores, we should materially increase the production of our furnaces.

At this stage, the President adjourned the meeting until 2.30 in the afternoon.

(To be continued.)

THE LATE DR. ALFRED J. AMSLER.

ENGINEERS and metallurgists in all parts of the world have learnt with regret of the death of Dr. Alfred J. Amsler, which, as recorded in our issue of last week, on page 468, occurred at his home at Schaffhouse, Switzerland, on April 2. Dr. Amsler, who was senior partner of the firm of Messrs. Alfred J. Amsler and Company, manufacturers of testing machines and instruments, Schaffhouse, was the second child of the late Professor-Doctor Jakob Amsler-Laffon, and was born at Schaffhouse on July 3, 1857. He received his general education at schools in his native town and afterwards studied mathematics and physics, first at Basle and then at other colleges on the Continent. He subsequently stayed some time in Paris and, in his early twenties, came to Scotland, where he spent several years, most of them in the shipyard of Messrs. William Denny and Brothers, Limited, Dumbarton. His long association with the Institution of Naval Architects commenced at this period of his life, his election as an associate of the Institution dating from 1884. In 1885, Dr. Amsler entered the business which his father had established in 1854, while still occupying the position of professor at the local



THE LATE DR. ALFRED J. AMSLER.

college. The young man's first task was that of improving and developing the design of the integrators invented by his father, and he was responsible for a number of ingenious modifications to these instruments.

At this point in his career, namely, during the late 'eighties of last century, Dr. Amsler designed an automatic cartridge-case sorting and filling machine, examples of which, we believe, are still in use in Swiss Federal Arsenals, although they were supplied over 50 years ago. Dr. Amsler also constructed a semi-automatic multiple dividing machine for use in the manufacture of slide rules. Shortly after his entry into the business, however, Dr. Amsler's father, while continuing to manufacture mathematical instruments, began to turn his attention to the construction of dynamometers and various power-measuring instruments, and, as the result of a suggestion by Professor Tetmajer, of the Swiss Federal Polytechnic School, to machines for testing materials. The first of these testing machines was built in 1886, and in their design Professor J. Amsler adopted the hydraulic principle for measuring the load applied. The inherent difficulty connected with this principle, namely, the friction set up between the measuring piston and its packing, was overcome in a manner similar to that adopted by the French physicist Amagat in his compression experiments on gases, by dispensing with packing altogether and grinding the piston to a very close fit in the cylinder. For use with these machines Dr. Amsler and his father designed their mercury load indicator and oil-mercury transformer, which equipment was extensively employed.

For a number of years the hydraulic principle was used in the Amsler tensile testing machines merely for measuring the load, the stress being applied by a screw and gear-wheel mechanism. In the belief that the hydraulic principle should be employed for applying the load as well as for measuring it, Dr. Amsler set to work to design a high-pressure oil pump which would give a delivery as free from pulsations as possible. The type finally adopted was the cam pump, which is still in use at the present time. He also designed and constructed two pieces of apparatus which have since been very widely employed in mechanical testing, namely, his oil-delivery regulator and his pendulum load indicator, which he called the "Pendulum Dynamometer." By the use of the oil-delivery regulator, the rate of application of the load in the tensile-testing machine is automatically maintained constant until fracture of the specimen takes place. The use of the Pendulum Dynamometer, which was first employed in 1910 for measuring the oil pressure (or tensile load) applied to the specimen, was afterwards extended to all types of tensile testing machines manufactured by the firm.

During the course of his career, Dr. Amsler witnessed the slow change from simple static testing to the impact, abrasion, and fatigue testing of metals and alloys. He was responsible for a number of developments in connection with impact-testing machines, and designed several devices for determining the energy expended in fracturing the test piece; he also devised a rope brake for checking the hammers of pendulum impact-testing machines during the return swing. The Amsler abrasion-testing machine, numbers of which are in use in various parts of the world, was developed for testing the wearing properties of metals and alloys employed in railway engineering. In his later years, Dr. Amsler's principal contribution to the science of fatigue testing was the machine which he called the "Pulsator." This machine, which has been described in our columns, subjects the test piece to alternating stresses varying in accordance with a sine curve, between two limiting loads.

In addition to the construction of machines for the testing of materials, Dr. Amsler was responsible for the design of dynamometers for investigating the performance of machine tools, torsion dynamometers for determining the output of turbines, and railway dynamometers. He also devised or improved a number of measuring instruments, among which may be mentioned a pantographic planimeter, known as the Durand-Amsler radial planimeter; hydraulic current meters for use in the investigation of the flow of water in rivers, channels and large-diameter high-pressure pipe lines; and recording and integrating gauges for use in connection with Venturi meters and similar equipment. In spite of advancing years and failing eyesight, Dr. Amsler continued in activity until a few months ago. He used to walk daily from his house outside Schaffhouse to the works in the town, and not only took a large share in the direction of the establishment, but also spent a good deal of his time in experimental and research work. The outbreak of the war, however, deeply affected him, and hastened his end. He was the recipient of many honours, probably the most recent of which was the award, by the French Government, of the Cross of Chevalier of the Legion of Honour in 1932.

STEATITE POST INSULATORS.—The design, construction, testing and performance of the post insulators and other products manufactured by Steatite and Porcelain Products, Limited, Stourport, are dealt with in a new and comprehensive catalogue of which we have recently received a copy. In the absence of any standard specification devoted particularly to post insulators for air-break switchgear, these products have been designed to comply as far as possible with B.S.S. 137-1930, which deals generally with porcelain insulators for overhead lines. As, however, the procedure for carrying out flash-over tests given in this specification differs from that in the corresponding document issued by the American Institute of Electrical Engineers, the flash-over characteristics laid down in the catalogue are in accordance with both the British and American specifications. Full test data for each type of insulator is clearly set out, the result being that the publication is a worthy addition to the technical literature issued by Imperial Chemical Industries, Limited, and its associated firms.

THE LATE MR. G. W. PARTRIDGE.

WE regret to record the death of Mr. G. W. Partridge, which occurred at Woldingham, Surrey, on Friday, May 3, at the age of seventy-five. Mr. Partridge was well known as a pioneer in the field of alternating current electricity supply. He was one of Ferranti's young men, and spent the whole of his working life in the service of one concern.

Gerald William Partridge was born in London, on June 22, 1864, and received his technical education at the old Hammond College, the forerunner of the present Faraday House. Having served his apprenticeship with the Anglo-American Brush Company, he joined the London Electric Supply Corporation in 1888, at the time when the famous Grosvenor Gallery station was being erected. Here he assisted Ferranti in changing the old series system of working transformers devised by Gaulard and Gibbs to parallel working and in experimenting with transmitting energy at 10,000 volts, one hundred 100-volt lamps in series being used as the load. In 1889, the generating station at Deptford, which was the first in this country to utilise the system of alternating-current generation and transmission over a distance, was opened by Ferranti and was utilised in parallel with the Grosvenor Gallery station to supply electricity in the west end of London. The connection between Deptford and Grosvenor Gallery was made by concentric mains consisting of two copper tubes, the insulation being paper impregnated with ozokerite wax, such as was used for candles. These cables were hand-made in 20-ft. lengths, and considerable trouble was experienced with the 7,000 joints, both during laying and in service. Nevertheless, they performed their duty well, and it is only a few years since the last length was taken out. The combination of stations mentioned had not been running very long, however, before a transformer failure set fire to the Grosvenor Gallery station. As a result, a complete change-over was made from the old 2,500-volt overload distribution system with both poles earthed to an underground concentric system with one pole earthed.

A great deal of the time of Ferranti and those engaged with him in the operation of the London Electric Supply Corporation was taken up not only with the design, but with the manufacture of the alternating-current equipment required. In this work, Partridge played a useful part. He was wont to exhibit with pride an air break switch with blades 10 ft. long which he had erected on the wall of the Deptford station, while in 1892 he was the first to design an oil circuit breaker, the principle of which is still in use to-day, though there have, of course, been great improvements both in design and performance. The most important part of Partridge's work at this time was to keep the system running. The failures were many, because the plant was of novel and not particularly sound design. The experiences gained were, however, useful, especially to those who have followed. Nevertheless, the burden for a time became too great, and in April, 1900, Deptford was shut down for nine months, primarily due to trouble with the boilers and auxiliary machinery. With the increasing use of electricity for all purposes the fortunes of the company, however, changed for the better, and prosperity was before long attained.

A short time later the London Electricity Supply Corporation was associated with another interesting problem, when it became necessary to give a single-phase supply at 7,000 volts to the London, Brighton and South Coast Railway for traction purposes. Heavy short-circuits were frequent and the power factor was apt to fall as low as 25 per cent., with disastrous effects on the alternator fields. Fifteen years ago, the operations of the London Electric Supply Corporation were modified by the London Electricity (No. 2) Act, and became mainly concerned with distribution, while the generating plant at Deptford was transferred to the London Power Company and has since been greatly extended. In fact, the station which is now at work on the site of Ferranti's original plant, and is known as Deptford East, has an installed capacity of 138,750 kW, while alongside it is the newer Deptford West station, with a capacity of 215,000 kW.

On the formation of the London Power Company Mr. Partridge was appointed joint chief engineer with the late Sir Alexander Kennedy, and when the latter died a short time later he acted as chief engineer until the appointment of Dr. (now Sir Leonard) Pierce, in 1926. At the time of his death he was a director of the London Electric Supply Corporation, having been chief engineer for many years, and also occupied a seat on the board of the North Wales Company and a number of other undertakings.

Mr. Partridge was elected an Associate of the Institution of Electrical Engineers in 1891 and was transferred to the class of Member in 1896. He had served on the Council and as vice-president. He was elected an associate-member of the Institution of Civil Engineers in 1894 and was transferred to the class of member in 1901.

THE LATE MR. C. FARADAY PROCTOR.

WE also regret to announce the death of Mr. C. Faraday Proctor, which occurred at Chiswick on Saturday, May 4, at the age of seventy-nine. He was a great-nephew of Michael Faraday.

Charles Faraday Proctor was born at Newcastle-on-Tyne on February 16, 1861, and after serving his apprenticeship with Messrs. Watson and Sons in that city entered Swan's private laboratory to assist him in the development of his well-known carbon lamp. In 1881 he went to Paris with Mr. (now Sir) James Swinburne to start a factory in that city, and after a period in England designing improved machinery for the Swan works in the north of England, went to Lille, where he became manager of the factory that had been established there. When the Edison and Swan Continental companies were amalgamated shortly afterwards, under the title of La Compagnie Générale des Lampes Incandescents, it was decided to build a new factory at Ivry-sur-Seine, of which he was given control. His work in this direction was recognised by the award of a bronze medal at the Paris International Exhibition of 1889. In the same year he re-joined the Edison-Swan Company in this country and was appointed assistant manager of their Ponders End works, shortly afterwards becoming manager of their fittings department. In 1900, he was transferred to the South Benwell factory, where he acted as manager until his retirement. During the course of his active career he introduced many improvements into the machinery for the manufacture of incandescent lamps. In particular, he designed a pump which made the production of the high vacua necessary for exhausting the bulbs easier and more efficient.

Mr. Proctor was elected a Member of the Institution of Electrical Engineers in 1894 and had served as chairman of the North-Eastern local centre. He became a member of the Institution of Mechanical Engineers in 1895.

"PERMITOL" LIQUID DIELECTRIC FOR TRANSFORMERS.

IT has long been recognised that the presence of large quantities of mineral oil in transformers constitutes a fire hazard which may be serious in certain types of installation. The consequent demand for a non-inflammable substitute has led Messrs. The British Thomson-Houston Company, Limited, Rugby, to develop a liquid dielectric, consisting of a mixture of chlorinated hydro-carbons, which is known as Permitol. This material, which has been in successful commercial service for eight years, is non-inflammable, and the gases evolved either by evaporation or an arc are also non-inflammable and non-explosive. It is chemically stable and inert, and does not sludge or acidify over long periods at temperatures up to 150 deg. C. It is practically non-hygroscopic and is much heavier than water, so that any moisture will float on its surface. Its electric strength is as high as that of mineral oil, and its viscosity and cold setting point are lower. The specific inductive capacity is nearly the same as that of the solid insulating materials used in transformers. Consequently, there is a better distribution of the dielectric stress than with mineral oil.

Transformers with Permitol liquid dielectric are, generally speaking, designed to comply with the relevant British Standard specifications. Their detailed construction is, however, somewhat different owing to the solvent action of Permitol on some of the materials normally used and to the necessity to minimise the volume of the dielectric on account of its high cost. For these reasons the core and coils are of material which is unaffected by Permitol and care is taken to make the design as compact as possible. Off-circuit tapping switches with handles for external operation are fitted as standard to avoid having to break hermetically sealed joints to change the taps. The tanks are of normal construction, except that tubes of special section are used to reduce the dielectric constant and the sampling valve is at the top instead of the bottom. The terminals are of the conventional type and the usual fittings are provided. Conservators and breathers are not, however, required, as the transformers are hermetically sealed. A vent is provided for the relief of internal pressure under fault conditions. This is designed to operate at a higher pressure than will be encountered in normal service. This vent should be connected to the outer atmosphere by a relief pipe. Where this is not possible, a gas absorber is fitted as the gases are unsuitable for human respiration.

The cost of transformers fitted with Permitol is relatively high. Their application is, therefore, limited to positions where the use of oil would be particularly hazardous, and where to install them some distance away from the load would lead to increased cable costs and losses.

LETTER TO THE EDITOR.

INFLUENCE OF SIZE ON THE FRACTURE OF NOTCHED-BAR TEST PIECES.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of January 5, 1940, on page 22, Professor B. P. Haigh refers to the influence of size of test piece in comparisons between brittle fractures in larger and smaller notched bars, and I would call your attention to an important factor in the problem. The principles, that the forces required for plastic deformation are proportional to the squares of corresponding linear dimensions in geometrically similar pieces (Fr. Kick, 1885) and that the quantities of energy absorbed in plastic deformation are proportional to the cubes, are applicable only when the distributions of stress and strain are uniform in the cases compared.

In notched bars subject to bending moment, this condition is not satisfied. At the base of the notch there is a concentration of longitudinal stress, and also, on account of the action of the metal situated at the sides of the notch, tension in the transverse direction. As plastic deformation requires a definite difference between these longitudinal and transverse principal stresses (Guest) the former increases when the latter intervenes; fracture is initiated by cracking at the base of the notch when the longitudinal tension overcomes the cohesion of the metal. As the stress in the transverse direction depends on the depth and form of the notch, these latter data are primarily responsible for the brittleness of a test bar of any particular metal selected.

This was shown experimentally by Retjö (International Congress for Testing Materials, New York, 1912) by a comparison between two series of notched bars tested in larger and smaller machines of the Charpy type. The linear dimensions of the test pieces, in which the notches were identical as regards size and shape, were in the ratio 3 : 1 as regards thickness of section above the notch, breadth of section and distance of span between the supports. The machines were of 75 m.-kg. and 10 m.-kg. capacity, with the same heights of fall in both cases; thus the ratios between the weight × leverage products were 75 : 10; and between the bending moments (75/10) × 3. The ratio between the values of the section moduli for the test pieces (B. T^2) was $3^3 = 27$, and the ratio between the stresses calculated in the usual manner was, therefore, 75/10 : 9, equal to 0·83, and therefore nearly equal to unity. It was found that the two series of tests gave the same values for the Charpy numbers.

I think therefore that the greater brittleness of large pieces, as compared with smaller pieces of the same steel, must have some origin other than the external geometrical dimensions. It seems probable that incidental defects and irregularities in large pieces may be deeper or of a more dangerous character in the larger than in the smaller if the brittleness is due to them and not to other circumstances.

Yours faithfully,
C. MIKLÓSI (Dr.-Ing.).

Timisoara,
Roumania.
February 20, 1940.

[NOTE.—We forwarded a copy of the above letter to Professor Haigh and his reply is given below.—ED., E.]

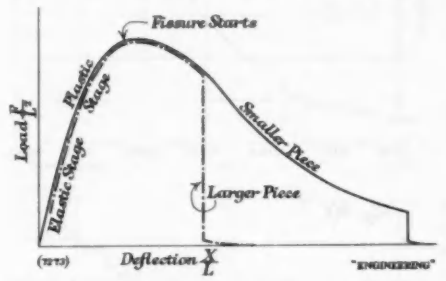
SIR,—Dr. Miklósi's letter calls our attention again to an unsolved problem of fundamental importance in engineering, and is particularly opportune at present as many engineers and scientists serving with H.M. Forces will study and contrast examples of brittle fracture in larger and smaller parts. War may be no time for deep reflection, but it offers notable opportunities for observation and leads in the long run to the advancement of engineering theory and practice.

The work of Fr. Kick in 1885 is of interest; and I would call attention to the still earlier and exceedingly thorough and philosophical work of the late Professor James Thomson—the elder brother of Lord Kelvin and an esteemed Professor of Engineering in the University of Glasgow. Thomson's original paper on the subject was read on December 21, 1875, and is to be found in the *Transactions of the Institution of Engineers and Shipbuilders in Scotland*. It had a marked influence on scientific thought in this country, led to further applications by Lord Rayleigh, in physical sciences, and by others in biology, and in the course of a few years was taken up also in Germany. As a graduate of the University of Glasgow, I was taught the idea and its practical application very clearly by the late Professor Barr, and have long benefited by its application in many fields of engineering practice in which I have been privileged to serve as a consultant. Nevertheless, to my astonishment, and perhaps also disappointment, I found by experience that its appli-

cation is apparently limited to elasticity and plasticity, and does not extend to cracking. This was forced on my attention first, as I say, by practical experience, and was confirmed only later by scientific investigation in the laboratory at Greenwich. The results that I quoted in the Eighth Andrew Laing Memorial Lecture afford an example, but only an isolated example, of a general conclusion that may be enunciated as follows :—

Although, during elastic and plastic deformation of geometrically similar objects by similar forces, the forces are proportional to L^2 and the energies are proportional to L^3 for deflections that are similar (*i.e.*, proportional to the linear dimensions L), the stages at which brittle cracking is liable to interrupt the course of plastic deformation and tearing are not such that the limiting deformations are proportional to L. The smaller pieces bend and tear farther than the larger ones before they eventually crack. This discovery, for so it was to me at the ti e, was entirely astonishing and disconcerting, more especially in view of my early training in Glasgow and subsequent experience in other directions not involving cracking in brittle manner. I have long continued to try out every suggested explanation that has been put before me—as well as a number that I, mysel , have devised from time to time—but up to the present I have found no satisfactory explanation.

Thomson's work does not support Dr. Miklósi's contention, that the application of the principles of mechanical similarity may be limited to uniform



distributions of stress and strain: on the contrary, it was shown very clearly in 1875 that the application includes non-uniform distributions in the plastic as well as in the elastic range; and Retjö's experiments do not appear to be validly citable, as the notches were identical in form and size although the other dimensions of the test bars were changed to maintain geometrical similarity. I concur in Dr. Miklósi's description of the complex stresses produced in the vicinity of the notch in tests on notched bars, and have offered this description with details on other occasions; but I do not see that it affects the application of the principles in question.

Fractures in ships and war material in general afford many examples of the contrast under discussion, and a theoretical advance of great practical value would be made if any engineer or scientist could recognise the cause. I do not doubt that the principles of mechanical similarity are, as Dr. Miklósi suggests, as applicable for brittle fracture as for plastic and elastic deformation, if only we knew the cause of the apparent difficulty.

The precise nature of the difficulty is illustrated in the accompanying diagram in which the force F, applied to bend a notched bar, is plotted against its deflection X; but, in order to make comparison more readily, the forces have been divided by L^2 and the deflections by L, in accordance with Thomson's principles. The graphs for the larger and smaller test pieces then coincide during the elastic and plastic stages that extend up to the peak of the graph, and continue to coincide even when the graph falls while ductile tearing is proceeding by the formation of one or more fissures originating at the bottom of the notch. The two graphs diverge suddenly at a somewhat later stage, when the larger bar fractures suddenly by cracking, although the smaller continues to bend and tear much farther before cracking, although it may crack later as indicated on the right of the graph. It is feared that the small test pieces generally used for notched-bar tests afford little or no indication of the liability of larger pieces of the same metal to crack in practice at much earlier stages of plastic deformation.

Yours faithfully,

B. P. HAIGH.

Royal Naval College,
Greenwich.
March 30, 1940.

VOLK'S ELECTRIC RAILWAY, BRIGHTON.—The celebrated Volk's Electric Railway, which runs along the front at Brighton and the first portion of which was completed and opened for traffic in August, 1883, has recently been acquired by the Brighton Corporation.

LABOUR NOTES.

THE report of the United Patternmakers' Association for the year 1939 states that the gross income was 82,437*l.* 14*s.* 5*d.*, which included 9,191*l.* 8*s.* National Health Insurance, 9,922*l.* 13*s.* 2*d.* State Unemployment Benefit, and 208*l.* 17*s.* Political Fund. The total was less by 10,059*l.* 14*s.* 5*d.* than in 1938. The gross expenditure was 58,482*l.* 4*s.* 9*d.*, which included 9,058*l.* 7*s.* 5*d.* National Health Insurance, 9,099*l.* 4*s.* 8*d.* State Unemployment Benefit, and 237*l.* 6*s.* 9*d.* Political Fund. The total was 19,390*l.* 11*s.* 10*d.* less than in 1938. The net trade-union income was 63,632*l.* 17*s.* 7*d.*—an increase of 2,910*l.* 9*s.* 11*d.* as compared with 1938—and the net trade-union expenditure 40,555*l.* 18*s.* 9*d.*—a decrease of 4,837*l.* 13*s.* 6*d.* as compared with 1938.

Under an agreement between the Air Ministry and the Government Minor and Manipulative Grades Association, about 1,500 civilian instructors employed by the Air Ministry are to get immediate increase of salary ranging up to 12*s.* 6*d.* a week. There will be two grades of pay, operating as from March 1, in each of the three grades of civilian instructors employed by the Ministry, 80 per cent. to 85 per cent. of the men affected being in the classes carrying the higher scale of pay. This follows a similar agreement arrived at recently with the Ministry of Labour and National Service on behalf of instructors employed in Government and local training centres. The Instructors' Association, it is stated, is now prosecuting a claim on behalf of its members employed by the War Department.

The Ministry of Labour and National Service has issued a revised list of reserved occupations, which includes six more trades which have been added to the schedule. Ages (shown in parentheses) have been amended in the following occupations:—Plastics and plastic-goods manufacture (23), asbestos opening, spinning and weaving (25), asbestos-cement goods manufacture (25), general stoneware manufacture (25), lighterman (18), galvaniser, tinner (21), brazier (18), slaughterhouse worker (25), cotton textile trades, including rayon weaving (25), leather tanning (25), currying, leather dressing (25), aircraft workers (18). The following new entries have been made in the schedule:—Asbestos-composition goods, including brakes and brake-linings manufacture (30), cinema employees (25), voluntary hospital staffs (25), electrically-propelled goods vehicle (25 and 30), typewriter ribbon, carbon paper, and stencil manufacture (30), engineering insurance inspection (25).

Moving the second reading of the Workmen's Compensation (Supplementary Allowances) Bill in the House of Commons last week, Sir John Anderson, the Home Secretary, said that under the measure every case in which an additional allowance was given would be one in which hardship might be presumed. Not only would there be no means test, but they would, he hoped, be able to avoid altogether anything in the nature of vexatious inquiry. The cost to any industry under the Bill should not represent, it was reckoned, more than a 25 per cent. increase, and the total cost would be rather under 2,000,000*l.* He was informed that there was no intention to alter premium rates, and the insurance companies had given him the fullest assurance that they would not discriminate on the basis of the family responsibilities of employees.

Mr. Arthur Greenwood moved an amendment refusing assent to the Bill because it was limited to a system of supplementary allowances in respect of wives and children, excluded any provision for single men and women, and therefore failed to recognise the admitted necessity for an immediate all-round increase in the rates of compensation payable. The amendment was negatived by 175 votes to 135, and the Bill was read a second time.

Following representations by the Trades Union Congress, the Minister of Health has issued a circular (No. 1994, April 17, 1940) outlining the procedure by which the superannuation rights of local government employees who transfer to armaments work, including shipbuilding, and repairing, may be safeguarded. For the purposes of the Act, the Minister will recognise such work as "war service," provided the consent of the employing local authority is obtained, and (1) the men are surplus to the essential requirements of the authority, and (2) arrangements for the transfer are made with the local branch of the Ministry of Labour and National Service. The Ministry is seeking the help of local authorities in securing the release of skilled engineers who should be provided with a certificate by their local authority sanctioning their release. On presentation of the certificate—preferably during normal working hours—at the local office of the Ministry of Labour and National Service—the employee will be notified of suitable vacancies, and, if he is engaged, the name and address of the employer will be communicated to the local authority by the Ministry of Labour and National Service.

The conditions under which further large numbers of women will be admitted to employment in certain branches of the engineering industry were discussed at two conferences in London last week. One was between representatives of the Transport and General Workers' Union and the General and Municipal Workers' Union and representatives of the Engineering and Allied Employers' National Federation, and the other between representatives of the Amalgamated Engineering Union and representatives of the Engineering and Allied Employers' National Federation. Further meetings are expected to take place shortly. At the conference with the A.E.U., it is understood, the employers submitted definite proposals which the representatives of the union took away for the consideration of their executive council.

Revised figures relating to rates of wages in 1939 are given in the April issue of *The Ministry of Labour Gazette*. There was little change, it is stated, in the general level of wages rates during the first eight months of the year. After the outbreak of the war, however, and particularly during November and December, increases in wages were granted in many industries, and at the end of 1939 the average level of wage rates was appreciably higher than at the end of 1938. In those industries and services for which statistics are regularly compiled, the changes in rates of wages reported to the Ministry of Labour and National Service as taking effect in 1939 resulted in an aggregate net increase estimated at about 940,000*l.* in the weekly full-time rates of wages of over 5,600,000 workpeople and in a net decrease of 8,500*l.* in those of about 6,600 workpeople. By the end of August, over 1,300,000 workers had received net increases estimated to amount to 114,000*l.* a week, and nearly 400,000 had sustained net decreases amounting to 40,000*l.* a week.

From September to the end of the year nearly 4¾ million people in these industries, some of whom had already received increases earlier in the year, had their rates of wages raised by an aggregate of nearly 830,000*l.* a week. These statistics are exclusive of changes in rates of wages in agriculture and certain other employments, in which there was also some increase in wage rates during 1939. In all the industries (including agriculture) for which information is available, the average level of weekly full time rates of wages at the end of 1939 is estimated to have been between 4 and 4½ per cent. higher than at the end of 1938.

Industrial and Labour Information states that an Order of the Presidential Committee of the Central Council of Trade Unions in the Soviet Union, dated March 15, defines the functions of insurance doctors in the service of trade unions. It is explained that although the supply of medical benefits to insured persons and their families is the province of the organs of the Commissariats of Public Health, the trade unions entrusted with the provision of benefits in cash have a certain number of insurance doctors in their service; these number 1,800. The Order provides that insurance doctors must help the unions to supervise the activity of public health institutions in the field of medical aid to workers and salaried employees and in the campaign against sickness.

Among the principal tasks imposed on them, the Order mentions the study of the causes of sickness in undertakings and establishments, the preparation and application of measures to prevent sickness in agreement with clinics and other institutions attached to the public health services, the supervision of the issue of sickness certificates by doctors in attendance, and the supervision of dietetic treatments and of the activity of committees entrusted with the task of assessing loss of working capacity, etc. Once a month, every insurance doctor must submit, to the Presidential Committee of the Central Territorial or Regional Committee or to the Insurance Council to which he is attached, a report on the morbidity rate among workers and salaried employees.

The insurance doctors have the right to visit undertakings and establishments and the canteens, communal dwellings, etc., attached to them, as well as the different establishments directed by the public health services, including clinics, maternity homes, children's nurseries, etc. When they observe breaches of the Acts and Regulations concerning health protection they must approach the responsible administrations to demand that these breaches shall cease.

MECHANICAL ENGINEERING IN POWER STATIONS.

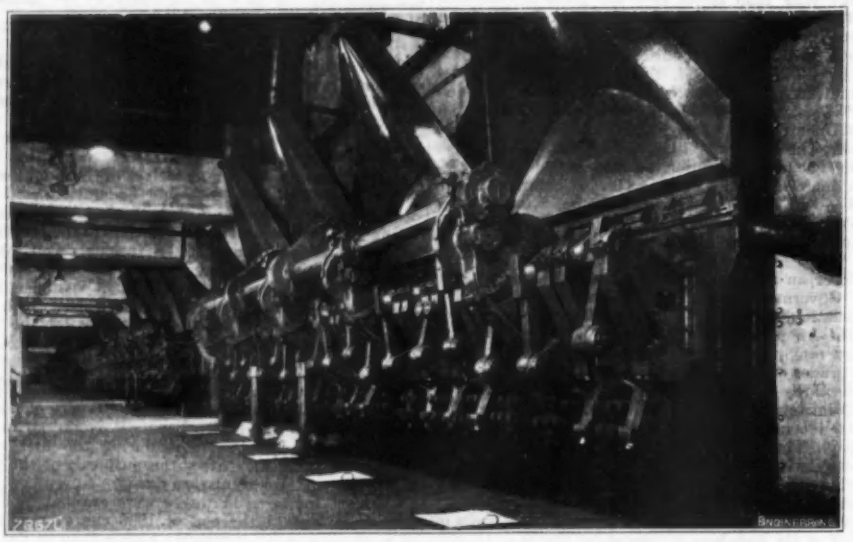


FIG. 36. FRONTS OF TAYLOR STOKERS AT BATTERSEA POWER STATION.

Fig. 37.

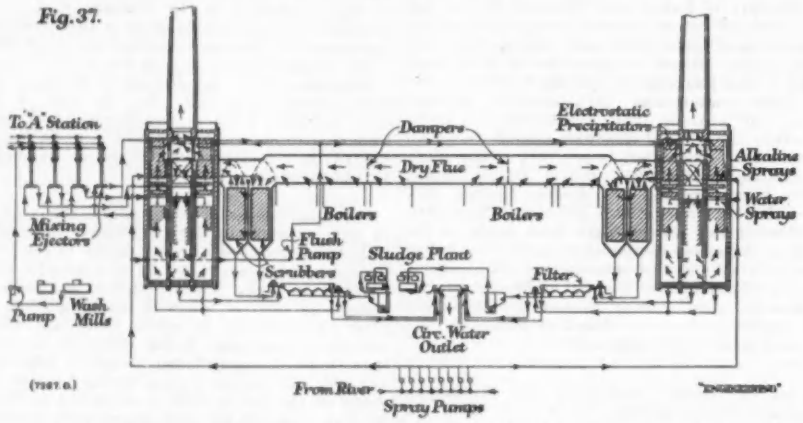


Fig. 38.

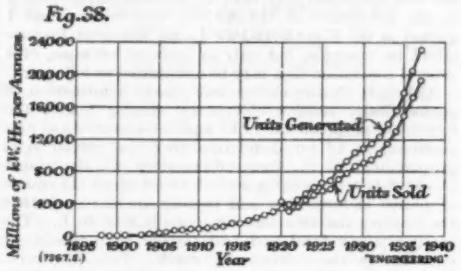


Fig. 39.

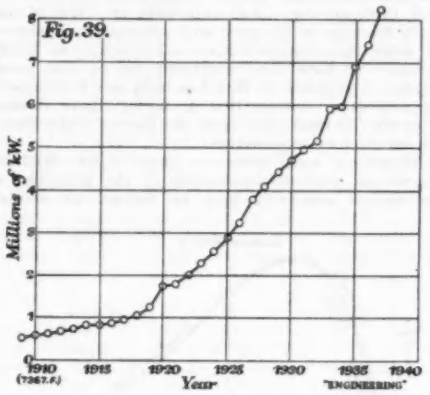
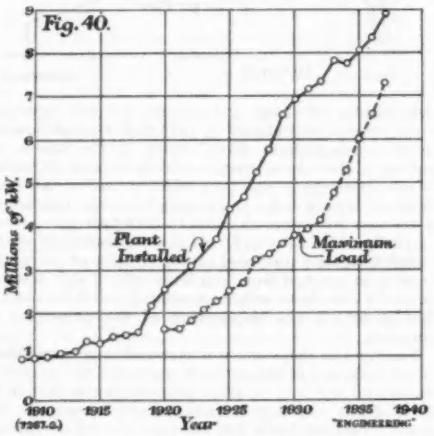


Fig. 40.



FORTY YEARS' DEVELOPMENT IN MECHANICAL ENGINEERING PLANT FOR POWER STATIONS.*

By SIR LEONARD PEARCE, C.B.E., D.Sc.

(*Concluded from page* 473.)

THE adoption of higher operating steam pressures has undoubtedly done much to bring the forced-circulation boiler to the front, due to the fact that, as the pressure is increased, the relative densities of steam and water at saturation temperature (upon which thermo-syphonic or "natural" circulation depends) alter so considerably. This is illustrated by Table XI, herewith.

TABLE XI.—*Variation in Density of Saturated Steam and Water at Various Pressures.*

Steam Pressure. Lb. per sq. in. abs.	Density of Saturated Steam. Lb. per cub. ft.	Density of Water at Saturation Temperature. Lb. per cub. ft.
200	0·437	54·4
350	0·753	52·3
600	1·29	49·8
1,200	2·77	43·6
1,500	3·61	41·8
2,000	5·3	39·2

Among other advantages claimed for the forced-circulation principle are:—(1) the ability to use tubes of much smaller bore and hence reduced thickness for higher operating pressures; (2) the reduction in number and, in certain instances, the entire elimination, of drums; (3) the freedom to dispose the heating surface to the greatest advantage with respect to heat transfer; (4) resulting from these three points, the ability to obtain a greater evaporation in a given space in the boiler house than is possible with natural-circulation boilers; (5) a reduction in weight and cost per unit output; and (6) absence of troubles from scale formation inside the tubes. As an offset against these advantages (some of which still remain to be proved) is the fact that the plant is complicated by the inclusion of pumping equipment, which absorbs power continuously, and to guard against the failure of which elaborate protective devices and controls must be provided.

The more familiar types of these boilers may be conveniently classified into two main groups, first those in which water is circulated, and second those in which steam is forced through the tubes. Most types operate on the former principle and these may be further subdivided into "forced-circulation" and "once-through" types. The La Mont and Velox are examples of ordinary forced-circulation boilers, and represent the least radical departure from the natural-circulation type. A pump is installed in the closed water circuit of the boiler and withdraws water from the drum, passes it through the tubes of the boiler heating surface, and returns the mixture of steam and water to the same drum, in which the separation of the steam takes place. The quantity of water circulated is about six to eight times the maximum continuous rating with the La Mont boiler and about ten to twenty times with the Velox, this quantity remaining constant irrespective of the loading on the boiler.

The "once-through" principle is used in the Benson, Sulzer, and Ramsin boilers. The main feed pump itself constitutes the circulating agent, and the feed to the boiler is regulated exactly by the steam output required, the distinguishing feature being the absence of any drums. The continuous circuit in the boiler is analogous to an economiser, boiler, and superheater in series, and at some point towards the end of the "boiler" and the beginning of the "superheater" sections the water is completely converted into steam. To overcome the resistance of the circuit the pressure at the inlet requires to be from 20 per cent. to 40 per cent. in excess of the final steam pressure. Somewhat elaborate control devices are required to regulate the feed and fuel quantities and the steam temperatures, etc. The well-known example of the steam-circulation type of boiler is the Loeffler, in which a steam drum is provided external to the boiler proper. A pump withdraws saturated steam from this drum and discharges it through tubes which constitute radiant and convection superheaters, the amount circulated being about three times the actual steam output of the boiler. One-third of the steam at the outlet of the superheaters is taken away to the turbine or other point at which the steam is required, and two-thirds are discharged back to the steam drum in which it gives up its heat to the feed water therein, to produce saturated steam. As distinct from the water-circulation boilers in which the pump output remains constant irrespective of load, the steam pump of the Loeffler boiler is varied in output according to the load on the boiler. This type of boiler can only be used economically in the steam pressure range from 1,700 lb. to 2,000 lb. per square inch, due to the excessive power which would be absorbed if lower pressures were used.

These various forced-circulation boilers have been developed principally on the Continent, and their application has been rather more in industrial plants than in power stations. However, there are now quite a number of boilers in operation or under construction in this country, as may be seen from the list given in Table XII. on the opposite page.

The 210,000 lb. per hour mechanical stoker-fired Loeffler boilers, which Captain Donaldson has installed at the Brimsdown "A" station of the North Metropolitan Electric Power Company, have now been in operation since the end of last year.* There are other

* The 26th Thomas Hawksley Lecture, delivered before the Institution of Mechanical Engineers, in London, on Friday, January 19, 1940. Abridged.

* See ENGINEERING, vol. 147, page 614 (1939).

special designs of boilers, such as the "Steamotive," the Schmidt, the Cantieny, the Foster-Wheeler, the mercury-vapour boilers, etc., although these are not all of the forced-circulation type.

All early boilers were fired by chain-grate stokers, the modern counterparts of which are known as mechanical stokers. While the fundamental principle remains the same, certain developments have taken place which have greatly improved the combustion-air supply and the control by "compartmenting." There have also been improvements in the design of the links or louvres forming the grate surface itself. The application of an "overfire" preheated air supply has also proved beneficial.

More recently, the retort stoker has been developed, and some excellent results have been achieved. All the boilers installed in the Deptford West and Battersea stations in recent years have been of this type and at the latter station the actual running boiler efficiency over the years has been over 88 per cent., based on the gross calorific value of the fuel. A view of the firing aisle showing all nine stoker fronts of the 375,000-lb. per hour Battersea boilers appears in Fig. 36, on the opposite page.

Pulverised-fuel firing, being a more modern development than mechanical stoking, received a great impetus when it was first desired to make large increases in boiler outputs. It was felt that the designs of mechanical stokers then available would impose a restriction. Such limitations cannot be said to exist to-day, at any rate so far as retort-type stokers are concerned. In the United States there is no doubt that the tendency is to use pulverised-fuel firing almost exclusively for large boiler units, though in this country this is not so marked.

The upward trend of boiler pressures and temperatures has resulted in the complete disappearance of the old type of open feed hotwell tanks. Modern conditions require a reduction of the oxygen content of the feed water to an absolute minimum. All modern systems, therefore, are of the "closed" type and provide for the introduction of the feed in a de-aerated condition. Because of the requirements of the modern high-duty boiler in the matter of purity of the feed, integral evaporating units have become a necessity for the production of the requisite feed "make-up." These units may generally be disposed to economic advantage in relation to the feed-heating system.

Much development work has been carried out in recent years in connection with multi-stage feed heating systems, and considerable economic gains have attended this progress. The placing of the heater units in advance of the boiler pumps, particularly in the case of the higher pressure installations, has called for the exercise of a high standard of design and manufacturing technique. The same observations apply to the evolution of the modern boiler-feed pump of the rotary type. While perhaps not strictly within the scope of this lecture, mention may be made of the wealth of chemical research devoted to the important problems associated with the conditioning of water within the boiler unit. To secure optimum operating conditions, in view of the very high working temperatures and pressures in use to-day, dosage equipments have been evolved for the application of the necessary chemicals under working pressure.

Flue-gas washing plants were referred to in the earlier part of my lecture. The Battersea plant has operated satisfactorily since its inception and has met the stringent requirements laid down by Government departments to obviate atmospheric pollution and to prevent water pollution as required by the Port of London Authority. The results have formed the subject of various Government White Papers. As is to be expected with any plant of new design, a few initial troubles were experienced, but these proved to be of a very minor character and the plant, as in successful operation to-day, is substantially the same as the original design.

So satisfactory has been the effectiveness of this plant that for the second half of the station—Battersea "B"—an extension of the system is being adopted, the only essential difference being that, instead of carrying out the first stage of washing in a large main flue running alongside all the boilers, it is now proposed to perform this function in special chambers situated in two bays at each end of the line of boilers, using a dry flue for connecting the fan discharges to the two chambers. A diagrammatic arrangement of the plant for the Battersea "B" station is shown in Fig. 37, opposite. To give some idea of the magnitude of the problem, it may be mentioned that the existing plant in Battersea "A" station removed, in the year 1938, 3,680 tons of sulphur from a total of 465,000 tons of coal burnt.

Another well-known example is the Howden-I.C.I. plant installed by Messrs. Preece, Cardew and Rider in the Townmead station of the Fulham Corporation. This plant differs in principle of operation from the Battersea plants in that it is a non-effluent system. The published results for this plant show that it is also giving excellent service and has fully complied with the various Government requirements. The necessity for gas-washing plant should only arise in the case of large stations which it is desired to erect in certain areas. Notwithstanding the capital and operating costs of such plants, it can be proved that it is in many cases more economical to place a power station as near as possible to the centre of the electrical load, where the alternative would be the removal o the station to a site involving many miles of underground transmission.

It appears fitting to conclude this lecture by a reference to the general growth in the demand for electricity over the period considered. In Fig. 38, opposite, are shown the annual figures for the units of electricity sold by authorised undertakers in Great Britain since the beginning of this century and for the units generated since 1920. The latter shows an increase of no less than 437 per cent. in 17 years. In the United States, the total annual generation of electricity has increased from 43,555 million units in 1920 to 120,996 million units in 1937, corresponding to an increase of 178 per cent. over the same 17-year period. It is estimated that world production has increased from 310,000 million units per annum in 1929 to 470,000 million units in 1937, an increase of over 50 per cent. in only eight years.

This increase in consumption has been accompanied, of course, by a corresponding growth in instantaneous loads to be carried, and in Fig. 39, opposite, are shown the aggregate maximum demands on authorised undertakings in this country between the years 1909 and 1937. The generating capacities of stations have had to be increased to cope with these loads, and Fig. 40, on the same page, shows the total installed capacity of all generating stations owned by authorised undertakers in this country, and the aggregate of the maximum demands on those stations. These curves are interesting in that they illustrate the effect of interconnection brought about by establishing the grid in 1930, by which it has been possible to reduce substantially the amount of spare plant which would have been necessary if each undertaking had to carry sufficient plant to provide for all local emergencies. These three diagrams, by displaying the rapid increase in consumption of electricity, explain in large measure why such great progress has been made in the size, design, and construction of the plant involved.

I think the two main lessons to be drawn from such a review as I have attempted are, first the importance of avoiding set ideas, and second the importance of breadth of view. In these days of ever-extending knowledge we all find it difficult to maintain contact with branches of engineering other than our own, but it is, nevertheless, of paramount importance to make this contact effective, if the milestones of the future are to mark the greatest progress on the ascent to the summit of achievement.

TABLE XII.—SPECIAL FORCED-CIRCULATION TYPE BOILERS INSTALLED OR ON ORDER IN GREAT BRITAIN.

Station.	Operating Company.	No. of Boilers.	Capacity.* N.E.R.	Capacity.* M.C.R.	Steam Pressure.	Steam Temperature.	Feed Temperature.	Air Temperature.	Method of Firing.	Notes.
			Lb. per hr.	Lb. per hr.	Lb. per sq. in.	Deg. F.	Deg. F.	Deg. F.		
La Mont boilers.										
Deptford West	London Power Co.	1	280,000	350,000	350	780–850	240	100	Retort stoker	
Willesden (Taylors-lane)	North Metropolitan Electric Power Co.	3	120,000	150,000	1,400	960	350–360	60	Chain grate stoker	
H.M. Ship ..	Admiralty ..	1	110,000	125,000	300	640	211	80	Oil	
Wolverhampton	West Midlands Joint Electricity Authority	4		120,000	400	850	315	90	Chain grate stoker	
British Dyestuffs (Huddersfield)	Imperial Chemical Industries	2		75,000	650	788	300	70	Chain grate stoker	
Wallerscote Works (Northwich)	Imperial Chemical Industries	1	60,000	75,000	800	777	356	100	Chain grate stoker	
West Bank ..	Castner Kellner Alkali Co. (Imperial Chemical Industries)	2	60,000	75,000	625	914	315–325	80	Chain grate stoker	
Works, Glasgow	G. and J. Weir ..	1	40,000	50,000	1,000	850	216	60	Chain grate stoker	
Sulzer boilers.										
Bargoed Colliery	Powell Duffryn Associated Collieries	2	110,000	130,000	1,565	770	445		Pulverised fuel	Also reheating at 366 lb. per sq. in. to 770 deg. F.
Warrington ..	Thames Board Mills	3	65,000	81,250	1,400	800	300		Chain grate stoker	
Loeffler boilers.										
Brimsdown "A"	North Metropolitan Electric Power Co.	2	175,000	210,000	1,900–2,000	932–940	355–362		Chain grate stoker	Also reheating at 200 lb. per sq. in. to 810 deg. F.
Brimsdown "B"	North Metropolitan Electric Power Co.	2	200,000	250,000	1,900–2,000	932–940	355–362		Chain grate stoker	Also reheating at 315 lb. per sq. in. to 840 deg. F.
Veloz boilers.										
Haslar Experimental Station	Admiralty ..	1		112,000	300	630	150–250	77	Oil	

* N.E.R., normal evaporation rating. M.C.R., maximum continuous rating.

CATALOGUES.

Press Brakes.—We have received from Messrs. F. J. Edwards, Limited, 359-361, Euston-road, London, N.W.1, a leaflet describing the Besco-Rafter all-steel press brake for motor drive.

Railway Trackwork.—Messrs. Hadfields, Limited, East Hecla and Hecla Works, Sheffield, have sent us a descriptive pamphlet dealing with railway crossings and other trackwork.

Precast Concrete.—The Bison concrete roof truss, evolved by Messrs. Concrete, Limited, Grand Buildings, Trafalgar-square, W.C.2, to avoid the use of steel and timber, is described in a leaflet recently received.

Fluorescent Discharge Tubes.—Messrs. The Edison Swan Electric Company, Limited, 155, Charing Cross-road, London, W.C.2, have sent us a leaflet describing the Royal Ediswan 80-watt fluorescent discharge tube.

Crusher Lubrication.—The lubrication of jaw crushers, as used for stone breaking, is the subject of a pamphlet recently received from Messrs. Hadfields, Limited, East Hecla and Hecla Works, Sheffield.

Spiral-Bevel Gears.—Messrs. David Brown and Sons (Hudd.), Limited, Huddersfield, have sent us a leaflet dealing with their industrial-type spiral-bevel gears, and also containing technical information for designers and users.

Wiremen's Pocket Book.—Messrs. British Insulated Cables, Limited, Prescot, Lancashire, have sent us a useful pocket book for wiremen and a leaflet giving particulars of their solid-setting and non-bituminous jointing compounds.

Valves.—Messrs. Hopkinsons, Limited, Huddersfield, have sent us a catalogue illustrating their range of small steel valves, including slide, check and non-return types, as well as strainers and micrometer valves for continuous blow-down.

Pumps.—We have received from Messrs. Rhodes, Brydon and Youatt, Limited, Waterloo Engineering Works, Gorsey Mount-street, Stockport, a leaflet describing the "Mopump," and, particularly, small vertical units of the sump-drainage type.

Welding Electrodes.—A leaflet illustrating and describing their shielded-arc method of welding, employing both mechanical slag protection and a gaseous deoxydising shield, has been sent to us by Messrs. Lincoln Electric Company, Limited, Welwyn Garden City, Herts.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification in each case, is given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

INTERNAL-COMBUSTION ENGINES.

517,881. Rotary Engine. Wilkerson Rotary Engine, Limited, of London, W. Quilter, of London, and J. S. Wilkerson, of Snaresbrook. (8 *Figs.*) August 9, 1938.—The invention is a rotary internal-combustion engine which is inexpensive to manufacture, is adaptable for various fuels, and possesses a low fuel consumption. Two cylinders 2 are formed in a cup-shaped rotor, and their inner ends are fitted with plane detachable cylinder heads. Each piston is connected to a common lever 10, mounted on a bearing on the driving shaft. Short links connect each arm of the lever 10 to composite bell-crank levers pivoted on the rotor. Each composite lever has a boss 19 carrying two resiliently connected arms, t e extremities of which carry rollers 31, 32. A third arm carries the link connecting it to the lever 10. The rollers run on a common fixed cam 29 bolted to one of the sup-

Fig. 1.

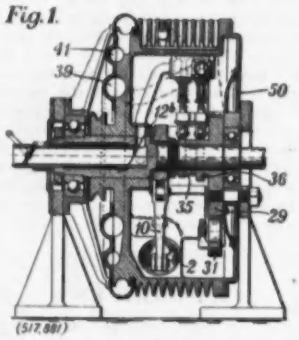
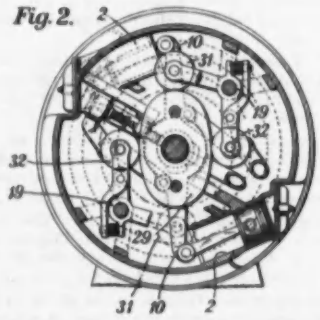
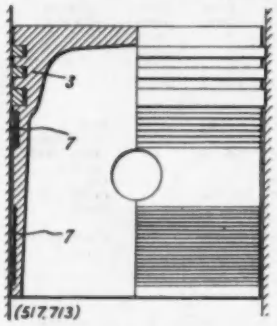


Fig. 2.



ports for the engine, so that the driving shaft passes through it. The operative rollers 31 control the motion of the lever 10 and the rollers 32 hold them in contact with the cam surface. The inlet and exhaust valves are operated by tappets bearing on a common inlet cam 35 and a common exhaust cam 36, both formed in one with the fixed cam 29. The mixture passes from the carburettor through the hollow end 12b of the shaft and through radial ports, one of which is masked while the other is opened. The exhaust gases are discharged into annular exhaust channels 39, 41, formed in the outer face of the rotor, and pass from the channel 41 into a peripheral groove of semi-circular section, which runs within a stationary collecting channel of U-section embracing the rim of the rotor and formed with a tangential exhaust pipe. The rotor has an end cover 50 and is partially filled with lubricating oil. In operation, the full four-stroke cycle is completed in each cylinder, once for each revolution of the rotor. At the beginning of the power stroke in one cylinder the piston tends to travel outwards and rock the lever 10 clockwise in Fig. 2. This movement is resisted by the link connection to the bell-crank lever 19, the latter being also urged in a clockwise direction to press the operative roller 31 on to the smaller-radius part of the cam 29. The levers, link and piston are, therefore, held stationary and the pressure rise within the cylinder causes the rotor to move anti-clockwise. As soon as this motion commences, the operative roller 31 begins to travel over the smaller-radius part of the cam 29, but this is so designed that the piston is held stationary in space until the cylinder head has moved away from the piston by a considerable part of the full stroke. Further rotation brings the roller on to the larger-radius part nearer the centre of the cam. In consequence, the lever 10 is permitted to rock clockwise relatively to the fixed cam 29 and the piston moves to the end of its stroke. The cylinder-head moves through 90 deg., while the piston only moves through approximately 60 deg. about the axis of the rotor. Continued rotation causes the operative roller 31 to ride on to the other smaller-radius part of the cam, and the piston is forced into the cylinder on the exhaust stroke. The induction and compression strokes are effected in similar manner. (*Accepted February* 12, 1940.)

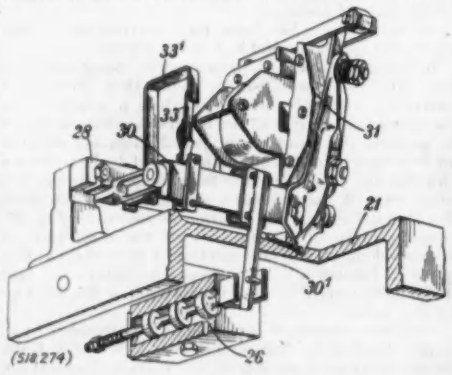
517,713. Piston for Aluminium Cylinders. The Automotive Engineering Company, Limited, of Twickenham, and A. V. Nicolls, of Headley, Surrey. (2 *Figs.*) March 17, 1939.—The invention is a piston which can be used in an aluminium-alloy cylinder block without sacrificing piston weight and without the necessity for the introduction of a steel liner which reduces the conductivity and adds to the weight, both of which features constitute the advantages of an aluminium block. To



avoid aluminium to aluminium bearing contact between piston and cylinder, the piston 3 is arranged so that a steel surface contacts with the cylinder bore. The figure shows one way of ensuring such a contact. The piston body 3 is of aluminium alloy and steel wire 7 is wound round the piston skirt in recesses and constitutes the bearing surfaces which contact with the cylinder. An alternative method is to construct the piston of a copper-steel alloy in order to increase the thermal conductivity, the copper being added in the proportion of from 1·50 to 2 per cent. (*Accepted February* 7, 1940.)

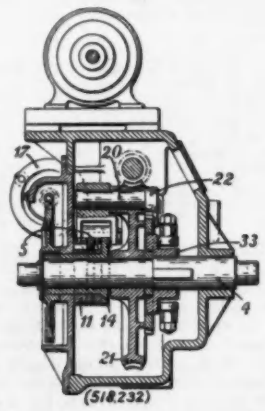
MACHINE AND OTHER TOOLS, SHAFTING, ETC.

518,274. Machine-Tool Controller. Wadkin, Limited, of Leicester, J. H. Goddard, of Stoughton, and W. L. Sims, of Leicester. (4 *Figs.*) August 18, 1938.—The invention is an electromagnetically controlled hydraulic mechanism for woodworking machine tools, and is particularly applicable to a cross-cut saw. In this machine a rotating saw is carried on a reciprocating ram and the length of its stroke is determined by limit stops which operate limit switches, one stop being adjustable. The hydraulic motor consists of a fixed cylinder and a piston connected to the



ram. Conduits connected one to each end of the cylinder each serve the purpose of both inlet and exhaust. A motor-driven pump draws oil from a reservoir, and delivers it to each conduit by way of a valve mechanism which controls the inlet or exhaust function of each conduit by a pair of piston valves 26. Each of these piston valves is opened by a contactor and is spring returned. The two contactors are mounted on the cover 21 of the oil reservoir and each consists of a fixture 28, electrically insulated from the remainder of the mechanism and carrying the stationary parts 33¹ of a switch and bearings for a short rocking bar 30. On the bar the armature 31 is mounted and the bar is connected to one of the two valves 26 by an arm 30¹, so that when the contactor is energised, the armature rotates the bar 30 and the valve is opened. On the bar is also mounted the moving part 33 of the switch which makes and breaks the circuit to the other contactor. The two contactor coils are in parallel and each circuit contains the switch of the other contactor and a limit switch operated by the reciprocating ram of the machine at one end of its travel. In the circuit to the forward-stroke contactor is an operator's control switch and a time switch, the latter being controlled by the return contactor. If the operator's control switch is closed, the ram makes the forward stroke. At the end of this stroke the forward limit switch is opened to de-energise the forward contactor and close the forward valve 26. As this valve closes, the associated contactor switch which is in circuit with the return contactor also closes and the return contactor is energised. This opens the return valve and also the switch in the circuit of the forward contactor, and the ram reverses. At the end of the return stroke the ram operates the return limit switch and a similar sequence of operations takes place. To provide for a dwell at the end of the return stroke, the time switch is included in the circuit to the forward contactor and is operated by the return contactor. It is arranged in series with the other switches in that circuit, and the arrangement is that when the return contactor is de-energised the time switch begins to close. The closing is delayed and the delay is adjustable. The time switch is opened each time the return contactor is energised, and it can be switched out of circuit if not required. (*Accepted February* 22, 1940.)

518,232. Intermittent-Drive Gearing. Stein and Atkinson, Limited, of London, and H. B. Higginbottom, of London. (4 *Figs.*) August 18, 1938.—The gearing is primarily designed for use in mechanical stokers, although it is suitable for other applications. A follower roller, which is carried on a crank arm, runs on a cam track 5 surrounding the driven shaft 4, but not connected to it. The cam track is composed of four cams side by side, the roller being of sufficient width to span them all. One cam portion is fixed while the others are adjustable between a position in which their crests are completely co-extensive and a position in which they slightly overlap. Each cam crest occupies somewhat less than 90 deg. of arc, and the cam nearest the end cover of the casing is formed on a fixed ring 11, the other cams being adjustable in relation to it, and formed on rings, the intermediate pair of which rotate upon a sleeve which is integral with the innermost ring 14 and freely surrounds the driven shaft 4. This sleeve is connected through worm gearing to a handwheel 17. The intermediate cams are engaged by pin and slot connections with the cams on each side,



so that when the innermost cam has been rotated clockwise until it extends beyond the others by its own length, its pin engages the end of the slot in the next cam and rotates the latter with it, and so on up to the maximum position. The crank arm is fixed on a spindle 20 mounted in the worm wheel 21, which is free to rotate on the driven shaft 4. The other end of the spindle carries a pawl 22, which co-acts with a ratchet wheel mounted upon the driven shaft. A spring holds the pawl in engagement with the ratchet wheel, from which it is periodically disengaged by the cam and roller. The proportion of each revolution of the driving member during which the pawl engages the ratchet wheel depends upon the adjustment of the cam. The ratchet wheel is connected to the driven shaft through a self-releasing clutch to protect the gearing against overload. The clutch consists of a flanged sleeve 33 sliding on splines on the driven shaft, and from the flange face dogs project into slots in the ratchet wheel. The driving faces of the slots and dogs are inclined so that during the periods of drive there is always a force tending to push the dogs out of the slots. Engagement is maintained by a spring, which yields when an overload arises. (*Accepted February* 21, 1940.)